Efforts to re-established Philippine crocodile *(Crocodylus mindorensis)* wild population in Southern Philippines

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A tri-partite crocodile conservation agreement between the Department of Environment and Natural Resources Protected Areas and Wildlife Bureau, the Silliman University and JKMercado & Sons Inc. was implemented in April 2006. Adult captive-bred *Crocodylus mindorensis* was released in semi-wild environment for conservation breeding at Pag-asa Farms, Kapalong Davao Del Norte without supplemental feeding. This was made through the effort of Crocodylus Porosus Philippines, Inc in their commitment towards the conservation of *C. mindorensis* including the facilitation for the release of captive-bred animals into the wild. Outcome of the program have resulted into a soft released re-introduction of Philippine Crocodile at the Lungaug Creek, Bgy. Katipunan, Sto. Tomas, Davao Del Norte in July 2009 and the benign soft-released introduction in Siargao Island Protected Landscape and Seascape in March 2013 which contributed to the considerable increased on Philippine Crocodile wild population. Conservation initiatives on the released of this threatened species in Southern Philippines is documented and presented.

The ecology and distribution of crocodiles in the Mahamavo wetlands of north west Madagascar

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The Nile crocodile, *Crocodylus niloticu*s, is the sole surviving member of Madagascar's historically speciose megafauna and its only large predatory species. The ecology of Nile crocodiles has been relatively well documented throughout its range on continental Africa however their ecology remains under studied in Madagascar. As is the case with the majority of other populations on the island, very little is known about the crocodile population in the rivers and wetlands of the Mahamavo water shed. Here we present distributional and preliminary ecological data based on two seasons of research during the dry season in the wetlands of Mahamavo, north-west Madagascar. We also provide an insight into human-crocodile conflict in the area based on opportunistic observations and the initial findings of a social science investigation. Current indications are that crocodiles in Madagascar have undergone an island-wide decline as a direct result of illegal harvesting of wild animals and habitat destruction. Our research reveals that even crocodile populations in relatively isolated areas do not remain unaffected by the drivers of this decline.

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN SSC Crocodile Specialist Group
pp 208 - 214

A new distribution record for the Philippine Crocodile (*Crocodylus mindorensis*, Schmidt 1935)

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Abstract

The presence of the Philippine Crocodile in isolated highland geologic depressions in locality Seven Lakes, Barangay Ned, Municipality of Lake Sebu in South Cotabato Province, Mindanao Island at altitudes 740-840 m ASL was documented for the first time in November 2012. This new distribution record is significant because all records of the species before this date pertain to altitudes lower than 700m above sea level. Description of crocodile artifacts, population status, community perceptions and importance to species conservation is presented and discussed.

Introduction

The Philippine Crocodile or Philippine Freshwater Crocodile (*Crocodylus mindorensis*) became known to science on the basis of skulls supposedly from the island of Mindoro in 1929 and were described as new species in 1935 by K.P. Schmidt of the Field Museum of Natural History in Chicago (Schmidt 1935). Knowledge on the distribution of this highly endangered species rest on the survey works of Charles A. Ross of the Smithsonian Institution/World Wildlife Fund Philippine Crocodile Project (Ross and Alcala 1983). The results of the Project led to the conclusion that *Crocodylus mindorensis* is one of the most threatened crocodilian species in the world with an estimated population of 500-1000 individuals existing in the wild throughout its range (Ross 1982).

Endemic to the Philippine Islands, this crocodile is likely to be found widespread throughout the country and is now actually found in inland freshwater habitats as remnant populations in north-eastern Luzon and central to southern Mindanao (Pontillas, 2000; van Weerd 2000; Pomares *et al*. 2008). Records on the occurrence in southern and northernmost islands indicate that the species exist in isolated populations on small islands with minimal habitats (Manalo 2008). In many instances, populations in central Philippine or Visayan Islands as well as in southern and central Luzon have been locally extinct (Ross 2008).

Populations of *Crocodylus mindorensis* in lowland rivers, lakes, marsh habitats, small isolated island (Ross and Alcala 1983; Oliveros *et al.* 2005) was investigated by naturalists in the country. By adding together the Cordillera Central, Abra Province, Luzon Island, Philippines as new locality and altitudinal record of this species in 2002 (Manalo 2008), the crocodile researchers have been challenged to re-evaluate potential crocodile habitats on the basis of altitudinal limitation in this supposed lowland species. Continued population reduction, decline in area of occupancy, and extent of occurrence and/or quality of habitat (IUCN 1996) have served as a challenge to searching for the species in viable habitats.

The Philippine crocodile is considered to be a severely threatened species needing conservation action with only estimated 100 adults believed to be surviving in the wild around the country (Ross 1998).

In November 2012, reports of crocodile hunting for local consumption prompted a survey in highland of Southern Mindanao, as part of the diversification program of Crocodylus Porosus Philippines Inc. (CPPI) in partnership with the DENR-Protected Areas and Wildlife Bureau (PAWB) of the Department of Environment and Natural Resources (DENR), Philippine Crocodile Rescue and Breeding Center (PCRBC), and the Environment and Livelihood Organization for Advancing Development. The main purpose is to obtain information on the presence and status of crocodiles in isolated wetland depressions and seasonal lakes of Lake Sebu, South Cotabato, southern Mindanao.

Methods

On 22-26 November 2012, a number of isolated geologic depressions such as highland crest and inundated basins (n=18) in freshwater wetland habitat of Seven Lake (word originated from "*Saving Lakes*"), Barangay Ned, Municipality of Lake Sebu, South Cotabato were investigated for the presence of crocodiles. Geographic coordinates and altitude were obtained by handheld GPS receiver (GARMIN *etrex* Summit HC).

Crocodile specimens from crocodiles slaughtered by locals in 2007 and 2009 were examined and photographed. Intact morphological characteristics that are visible for the basis of species identification were cautiously digitally drawn using CorelDRAW ver.11 2002 to reflect available distinguishing features. Scale counts were analyzed following Brazaitis (1971), Ross (1982), and Ross and Alcala (1983) with notes on the description of Schmidt (1935). Modified morphometric cranial indices by Hall (1989) adapted from Iordansky (1973) were used to describe and compare relative skull measurements. Due to scarcity on comparable works or ratios for estimating the body length from head length for palustrine or small crocodile species, Bellairs (1969) formula [Body length = 4.39 + (7.49 x head length)] for *Crocodylus niloticus* were used for our specimen.

Standard spotlight survey method was conducted to further assess the presence of remaining crocodiles in viable habitat. Rapid assessments of sites were adapted from Davies and Giesen (1991) set of preliminary ecological value and viability criteria. Current distribution in places known to have reported sightings, verified reports and secondary information by the local inhabitants were documented. Species awareness campaign particularly on the general importance of wildlife conservation with emphasis on crocodiles, habitat, behavior and its conservation was opportunistically conducted with key informant interviews.

Results

Twenty one highland crest and inundated basins or small lakes were visited and were examined the habitats for the existence of Philippine crocodiles. About 38% (n=8) of reported lakes have reports on crocodile sightings from 2007-2010.

Sun-dried skins from an adult and a juvenile crocodile were displayed in the residences of their captors, Mr. Enrique Besa and Mr. Ama Gugo respectively (Fig. 1). The skull from the adult crocodile, in the possession of Mr. Triveth Tupas, was collected by the research team through the authority of the Protected Areas and Wildlife Bureau of the Department of Environment and Natural Resources. These crocodiles were supposedly captured in Pugwan Lake (6°17'10.2"N, 124°26'19.6"E; 798 m ASL) and Pangalman Lake (6°18'03.3"N, 124°25'14.9"E; 753 m ASL), both of which are part of a land reform settlement (Presidential Proclamation No. 550 of 1969) that is permanently inundated. The area had been subjected to logging operations previously, and was converted into agricultural land that produced slightly turbid surface water draining towards a larger adjacent lake.

Figure 1. Mr. Rainier Manalo of CPPI, Dr. Cayetano Pomares of USM (left), local informant Mr. Triveth Tupas (center) with sun-dried skin and skull of an adult crocodile taken from Lake Pugwan in 2009; and Mr. Ama Gugo with Dr. Cayetano Pomares, Mr. Rainier Manalo with sun-dried skin of a juvenile crocodile (right) taken from Lake Pangalman. Lake Sebu 2012.

A local informant led the team to an area in Lake Pugwan where nests were located in 2007 and 2009. The area is located on the sloping areas of the marginal upland forest on the northeastern side, situated about 25 m uphill from the water's edge. It was recorded at a slope of 40° at an elevation of 801 MASL. This nesting site is characterized as mixed secondary and primary forest and karsts limestone formation. Parts of the lake were converted into farmlands utilizing surface water for agriculture. The nests were located approximately 10 m away each other, albeit laid in different years. Interviews revealed that local residents collect crocodile eggs for food.

Description of crocodile specimens - The dorsal scalation of the adult hornback skin from Lake Pugwan comprised of 17 transverse dorsal scale rows, 10 dorsal midbody scale rows (PC 10-15), and ossified dorsal armor. The condition of the skin did not allow counting of the ventral scale row, but the ventral scales were relatively large. In Lake Pangalman, the sun-dried hornback skin (76cm dorsal length) of a juvenile crocodile was inspected. It comprised 18 transverse dorsal scale rows, 10 dorsal midbody scale rows (PC 9-14), 23 large ventral scale rows from the cloaca to the thoracic collar, and ossified dorsal armor. The animal was estimated to be around 1.1 m long.

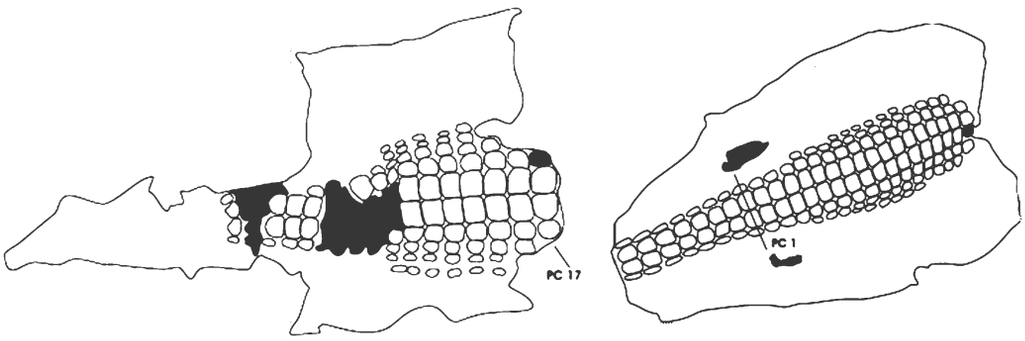

Figure 2. Sketch of a sun-dried skins from an adult (left) and a juvenile (right) crocodile taken from Lakes Pugwan and Pangalman respectively. Lake Sebu 2012.

Both sun-dried skin specimens (Fig. 2) had incomplete caudal scale rows and lacked nuchal shield cluster (PC 19-23) and post-occipital or occipitals (PC 24-26).

The skull showed a massive structure, distinctively broader and short snout of prominent maxillary angulation, prominent lachrymal groove, antorbital or maxillary ridge high and abrupt laterally, pronounced festooning of maxillary teeth, more rounded premaxillary with 5 teeth sockets, palatine-pterygoids suture nearly transverse and the length of maxillary symphysis is shorter than the length of premaxillary symphysis (MXS<PXS). Results on the relative growth of the examined skull specimen from Lake Pugwan (Table 1.) did not differ (χ^2 = 4.758, 8df, $P > 0.05$) with the relative growth range class mark of *C. mindorensis* skulls examined by Hall (1989). Two of the nine indices had conformed within the specified character size range of *C. mindorensis*.

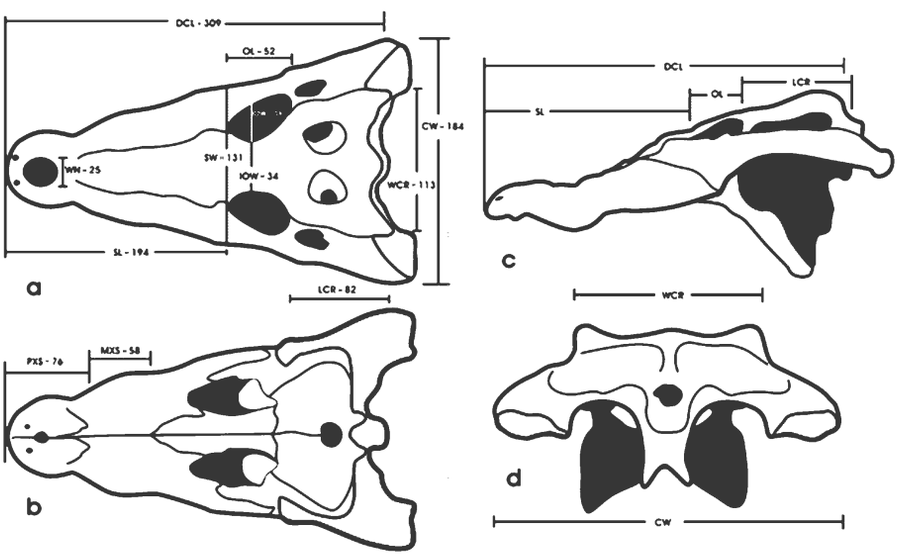

Figure 3. Dorsal (a), palatal (b), lateral (c), and posterior (d) view of skull specimen from Lake Pugwan, Bgy. Ned, Lake Sebu, Philippines showing measurements taken. DCL = dorsal cranial length, CW = cranial width, SW = basal snout width, SL = snout length, IOW = minimal interorbital width, OW = maximal orbital width, OL = maximal orbital length, LCR = length of postorbital cranial roof, WCR = posterior width of the cranial roof, WN = maximal width of external nares, PXS = length of premaxillary symphysis, and MXS = length of maxillary symphysis. 1mm.

* DCL = dorsal cranial length; RWST (relative width of snout) = (basal width of snout x 100)/snout length; RLST (relative length of snout) = (snout length x 100)/DCL; RCW (relative cranial width) = (cranial width x 100)/DCL; RWI (relative interorbital width) = (minimal interorbital width x 100)/maximal orbital length; RLR = (relative length of postorbital cranial roof) = (length of postorbital cranial roof x 100)/posterior width of cranial roof; ROL = (relative orbital length) = (maximal orbital length x 100)/ DCL; ROW = (relative orbital width) = (maximal orbital width x 100)/ maximal orbital length; RWN = (relative width of external nares) = (maximal width of external nares x 100)/ DCL snout length. (*adapted from Hall, 1989*).

Table 1. Comparative relative growth skull indices by Hall (1989) and Lake Pugwan skull specimen.

Character	*Crocodylus mindorensis* relative growth skull indices* by Hall (1989)			Lake Pugwan Skull Specimen
	Mean ± SE	Range	*Class Mark*	
DCL	227.7 ± 20.6	140-387	263.5	309
RWST	57.5 ± 1.0	51.9-66.3	59.1	67.53
RLST	63.3 ± 0.6	59.2-66.4	62.8	62.78
RCW	46.4 ± 1.4	43.9-49.8	46.85	59.55
RWI	53.1 ± 3.5	34.5-70.5	52.5	65.38
RLR	76.8 ± 1.1	71.2-84.2	77.7	72.57
ROL	15.8 ± 0.4	13.4-18.4	15.9	16.83
ROW	76.1 ± 2.0	65.9-91.3	78.6	69.23
RWN	19.2 ± 0.7	16.7-23.1	19.9	21.74

Based on skull measurements (Fig. 3), information on relative growth (Hall 1989), and total length estimate method of Bellairs (1969), the specimen was determined to be a *Crocodylus. mindorensis* of around 2.358 m total length (head length= 30.9 cm). Results on the dorsal scale patterns, palatine structure, cranial morphology and geographic location identify the animal to resemble the Philippine Crocodile.

Habitat structure and population status - Surveys of 21 of the more than one hundred highland crests and inundated basins or small lakes revealed no crocodiles, including 8 lakes where crocodiles were reportedly sighted between 2007 and 2010. Rapid site assessments on lakes with reported sightings revealed that a total of 3 wetland scored high on both ecological value and viability (Fig. 4). Among these are Lakes Ubodan, Pugwan and Pangalman, that are partly forested or partly in natural catchment condition. Majority of the reported sites have high ecological value.

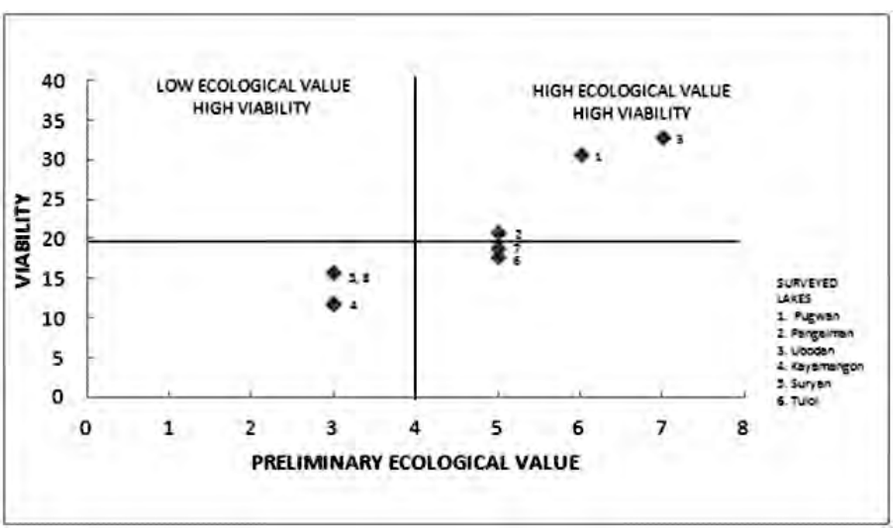

Figure 4. Scatter diagram of preliminary ecological value vs. viability (adapted from Davies and Giesen, 1991) of lakes with reported sightings in Seven Lake, Lake Sebu.

Highest value obtained by Lake Ubodan (6°18'10.8"N, 124°25'34.8"E; 792m ASL) is partly contributed by clear and greenish surface water habitat combined with layers of shrub and marsh associated vegetation (Fig. 5). Peripheral vegetation cover was partly surrounded by lower montane marginal forest in the western part while other areas adjacent to lake shore were herbaceous swamp and agricultural lands. The vicinity is composed of karst topography that is sparsely vegetated by dipterocarp trees, ferns, mosses and vascular plants associated with karst habitat.

Figure 5. Landscape of Lake Ubodan (left), Pugwan (center), and Pangalman (right). Lake Sebu 2012.

A further spotlight survey of Lake Ubodan in Seven Lake, Bgy. Ned, Municipality of Lake Sebu, revealed 7 or 8? eyeshines of non-adult crocodiles congregating at the shallow water's edge. These populations were presumed to be an extant population of Philippine Crocodiles. (There is a need to capture live crocodiles to confirm their identification as Philippine Crocodile.)

Combining the results of these preliminary surveys with interviews of key informants, there is an estimated 18 *C. mindorensis* (11 adult, 7 non-adult) in the 5 inundated basins of Seven Lake in Lake Sebu, between 740 and 840 m ASL.

Community awareness and perception - The presence of crocodiles locally known as *K'wangkug* (a T'boli local language for small crocodile living in lakes) is a common knowledge to the indigenous people living in the highland of Lake Sebu. Local residents of the study site recognized only one type of crocodile, describing it as small in size, with a yellowish back and white belly. Locals are aware that the lush vegetation of their wetland habitats contributed to the abundance of species in isolated lakes in the past. They are very much aware on the specific location where crocodiles appear to thrive. The remote and farthest community of Lake Sebu was converted to settlement sites a mono-crop plantation. Habitat conversion extends up to margins of the lake, and crocodiles are exposed for curiosity and target shooting.

Residents understand that the crocodiles are wary and do not attack humans. This behavior is characteristic of *C. mindorensis*. This behavior contributes to the locals' interest in crocodiles, including their utilization as a protein source. These hunting practices have resulted to the decline in the crocodile population and thus fewer interactions with humans. However, the common misconception about crocodiles generally showing aggression to humans and their livestock still persists.

Discussion

Since 1935, when K.P. Schmidt described *Crocodylus mindorensis* as new species, knowledge on the distribution on this species was limited on the localities presented by Ross and Alcala (1983) in their first and only comprehensive study on the distribution of Philippine crocodiles. Ross (1984) signifies that there is an insufficient knowledge on their preferred or required habitat. Philippine crocodile remains to inhabit minor pockets of habitats and none appears to be protected (Messel *et. al.*, 1992).

Basic understanding on the distribution in their natural habitat was mostly restricted in lowland freshwater habitat. An update on the status of crocodiles in the Philippines (Ortega *et.al.*, 1994) has recorded wild population in Busuanga Island. While the addition of an extant population of *C. mindorensis* in San Mariano, Isabela, Luzon Island and Pulangui River, Bukidnon, Mindanao Island (Pontillas, 1999) was documented from the works of U. Frederick Pontillas in his attempt to determine distribution, abundance, and population genetics of Philippine crocodile based on known distribution by Ross and Alcala (1983).

In summary, the Philippine Crocodile is considered to be a lowland species found in freshwater (rivers, lakes, marshes, small isolated island) habitats as remnant populations in north-eastern Luzon in the wetland pockets of Northern Sierra Madre foothills and several micro habitats in coastal towns of Isabela, Cagayan (van Weird, 2000), Dalupiri Island (Oliveros *et. al.* 2005 and Ross, 2005), and the presumed stronghold population in Ligawasan Marsh Game Refuge and Bird Sanctuary in Southern Mindanao (Pomares *et. al.* 2008). These localities have contributed to the significant picture of the distribution of this rare species and researchers have not done fieldwork on their possible presence in areas of high elevation.
In this paper, the analysis on crocodile specimens from the highlands of Lake Sebu, Mindanao Island revealed that the sun-dried skins and skull resemble those of *C. mindorensis*. Both sun-dried skin specimens had 17-18 transverse dorsal rows that matched with the scale character by Schmidt (1935), Ross and Meyer (1983), and Hall (1989). Cranium morphology measurements did not differ with the results on *C. mindorensis* relative growth of skull by Hall (1989). Total length estimate of around 235 cm. based on skull specimens taken in Lake Pugwan is within the size range estimate of

288-326 cm. (Ross and Alcala, 1983), 3.5 meters largest captive individual examined by Ross (1984), and slightly longer than the 217 cm. adult female crocodile captured and released in Caucauayan Creek, Dalupiri in 2005 (Oliveros *et. al*. 2005).

These results imply that the presence of *C. mindorensis* in this highland habitat of Lake Sebu on Mindanao is a new locality and altitudinal record (740-840 m ASL) for the Philippine Crocodile.

Our new finding on Mindanao and the occurrence of *C. mindorensis* in the Cordillera Central, Abra Province (Manalo, 2008) show that the Philippine Crocodile can thrive in lowland freshwater riverine and palustrine habitat to high altitude permanent and seasonal ponds including floodplain lakes. The existence of *C. mindorensis* in highland crest/isolated geologic depressions or small lakes in the vicinity of Lake Sebu, Southern Mindanao is a significant discovery as new locality and altitudinal record (700-850m ASL) of this species explored from 2002 to 2012. Owing to the presence of this species in two different biogeographic regions, suggested that altitude is not a limiting factor in the population distribution of Philippine crocodile. Messel *et. al*. (1992) noted that *C. mindorensis* are scattered on Mindanao and a few other islands in southern Philippines.

Conclusion

The existence of this supposedly "lowland" species in the highlands of Lake Sebu in southern Mindanao and in Cordillera Central, Abra Province, Luzon Island (recorded in 2002), suggests that altitude may not be a constraining factor when searching for potential habitat of this species. This can be considered as one of determining factors for their dispersal across terrestrial landscape. Historically, the Philippine Crocodile probably had a wider altitudinal distribution on various Philippine islands, large and small.

Recommendations

1. The highland central area of northern Luzon, Samar and Leyte and central Mindanao highland ridge along the provinces of Bukidnon warrants further fieldwork.
2. Higher elevation wetland ecosystem must be considered for re-assessment as potential Philippine Crocodile habitat.
3. In order to determine the original distribution of Philippine crocodile in the wild, historical distribution must be evaluated for species-habitat connectivity without considering the altitudinal limitation. (Try to include more pictures to illustrate details of habitats.)

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Literature Cited

01. Bellairs, A. (1969). The Life of Reptiles, Volume I. London: Weidenfeld and Nicolson.

02. *Brazaitis, P. (1971). Crocodylus intermedius Graves, a review of the recent literature. Zoologica 56:71-75.*

03. Davies, J. and Giesen W. (1991). Towards a Methodology for Identifying Tropical Freshwater Wetlands for Protection, Institute of Advanced Studies. Asian Wetland Bureau, Asian Wetland Bureau-Indonesia, Asian Wetland Bureau, Institute of Advanced Studies.

04. Hall, P. M. (1989). Variation in geographic isolates of the New Guinea crocodile (*Crocodylus novaeguinae* Schmidt) compared with the similar, allopatric Philippine crocodile (*C. mindorensis* Schmidt). *Copeia* 1989 (1): 71-80.

05. Iordansky, N.N. (1973). The skull of crocodilian Pp. 201-262. In: Biology of the Reptilia. Vol. 4. C. Gans and T.S. Parsons (eds). Academic Press, New York, New York.

06. IUCN. (1996). 1996 IUCN Red List Categories. IUCN species survival commission, IUCN Council; Gland, Switzerland. Pp.15-17.

07. *Manalo, R.I. (2008). Occurrence of Crocodylus mindorensis in the Cordillera Central. Abra Province, Luzon Island. In: Alba, E. & Lagartija, M. (Eds), National Museum Papers volume 14-2007 Edition Special Issue: Proceedings Forum on Crocodiles in the Philippines. National Museum of the Philippines, Ermita, Manila, pp. 109115.*

08. Messel, H.F., King W.F., Webb, G.J.W., and Ross C.A. (1992). The Present Status of the Two Species in the Philippines, the Analysis on the Activities of Crocodile Farming Institute (CFI), and the Future Strategy of Species Conservation. Summary report on the workshop on the prospect and future strategy of crocodile conservation of the two species (*Crocodylus mindorensis and Crocodylus porosus*) occurring in the Philippines. In: Crocodile Conservation Action. A Special Publication of the Crocodile Specialist Group of the Species Survival Commission of the IUCN-The World Conservation Union. Gland, Switzerland. P 98-101.

09. Oliveros, C., Manalo, R.I., Coñate Sr. E.G., Tarun, B., Telan, S., and van Weerd M. (2005). The Philippine crocodile recorded on Dalupiri Island. Crocodile Specialist Group Newsletter 24(3): 14-15.

10. Ortega, G.V., Regoniel, P. and Ross, C.A. (1994). Status of Crocodile in the Philippines, An Update. Pp. 115-154. *In*: Proceeding of the 12th Working Meeting of the Crocodile specialist Group, IUCN The World Conservation Union, Gland, Switzerland and Cambridge UK.

11. Pomares, C.C., Pomares, M.P. and Escalera, C.M.R. (2008). The existence of wild crocodiles in Ligawasan marsh and its tributaries. *In: Alba, E. & Lagartija, M. (Eds), National Museum Papers volume 14-2007 Edition Special Issue: Proceedings Forum on Crocodiles in the Philippines. National Museum of the Philippines, Ermita, Manila,* pp. 197-203.

12. Pontillas, U.F.A. (1999). The distribution, abundance, and population genetics and conservation Philippine crocodile. Six Month Project Report December 1999. Wildlife Conservation Society, Bronx, New York, USA. (Unpublished report). 6pp.

13. Pontillas, U.F.A. (2000). New breeding sites for the Philippine crocodile. Crocodile Specialist Group Newsletter 19(2): 10-12.

14. Ross, C.A. (1982). Final Report. Smithsonian Institution/World Wildlife Fund Philippine Crocodile Project. WWF Report (1489): 34.

15. Ross, C.A. (1984). Crocodiles in the Republic of the Philippines. *In*: Crocodiles. Proceeding of the 6th Working Meeting of the Crocodile Specialist Group, IUCN The World Conservation Union, Gland, Switzerland and Cambridge UK.

16. Ross, C.A. (2005). Crocodiles on Dalupiri. Crocodile Specialist Group Newsletter 24(1): 12.

17. Ross, C.A. (2008). A question of habitat - *Crocodylus mindorensis*. *In: Alba, E. & Lagartija, M. (Eds), National Museum Papers volume 14-2007 Edition Special Issue: Proceedings Forum on Crocodiles in the Philippines. National Museum of the Philippines, Ermita, Manila,* pp. 116-122.

18. Ross, C.A. and Alcala, A.C. (1983). Distribution and status of the Philippine Crocodile (*Crocodylus mindorensis*). Kalikasan: Philippine Journal of Biology 12(1-2): 169-173.

19. Ross, F. D. and Mayer, G. C. (1983). On the dorsal armor of the Crocodilia. *In*: Rhodin, A. G. J. & Miyata, K. (eds) *Advances in Herpetology and Evolutionary Biology*. Museum of Comparative Zoology (Cambridge, Mass.), pp. 306-331.

20. Ross, J.P. (Ed) (1998). Crocodiles, status, survey, and conservation action plan (2nd ed.). IUCN/SSC Crocodile Specialist Group. IUCN, Gland, Switzerland. 136 pp.

21. Schmidt, K.P. (1935). A new crocodile from the Philippine islands. Field Mus. Nat. Hist. Zool. Ser. 20: 67-70.

22. van Weerd, M. (2000). Update on Philippine crocodile occurrence in the Northern Sierra Madre Natural Park. Crocodile Specialist Group Newsletter 19(4): 12-14.

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pp 215 -218

Mugger crocodile (*Crocodylus palustris*) status and situation in Iran

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Abstract

Small population of Mugger crocodiles distribute in southeastern part of Iran, in sistan & Baluchestan province. The area is known as the western most global range of the species. The main characteristic of the population is that has been divided to several sub-populations and being scattered. As a management option, the main part of crocodile habitats has been designated as "protected area" and "International wetland site". The crocodiles occupy vast range of natural and artificial water bodies as their habitats. Crocodiles use any available resources as food like fish, birds, dogs and villager's livestock but they are mainly dependant on fish s. One of the most specific and important behaviors of Mugger is burrowing which is mostly used as refuge, even by the hatchlings. Any evidences indicating of nesting in the burrows not found in the studies. Migration or movement between habitats in different distances is another considerable behavior of Muggers which provides potential threat for the crocodiles that have to pass through roads resulting in death by car strikes. Fortunately, as a unique situation in the world, there is no hunting on crocodiles in Iran and local people based on their cultural beliefs respect crocodiles and never harm them, although they have very close contact with crocodiles. Drought and flooding remain as the main natural threats for the crocodiles. In the last consensus conducted in May 2012, totally 326 crocodiles directly were counted, but seems that the number should be more.

Distribution of Muggers in the region

Small population of Mugger crocodiles distribute in southeastern part of Iran, in Sistan & Baluchestan province. The area is known as the western most global range of the species. The population seems to be isolated and it has been divided to several sub-populations as well as being scattered in the area. Their habitats are along three main rivers of the area: Sarbaz, Kaju and Bahukalat and their related headwaters and ponds. Some part of this area with an extend of about 465000 ha due to its importance as crocodile habitat designated as "protected area" 1971 named Bahukalat and in 1982 renamed to "Gandou" protected area. Gandou is the local name for the crocodiles in the area. The main distributional area of Mugger in Iran starts from Sarbaz and southeastern part of Nikshahr along Kaju River which joins to Sarbaz River in its way to the sea. Sarbaz River renames to Bahukalat after the village with same name. Although Kollany village and its pond is are near Govater Bay which are considered as end of crocodile range in Iran, there is no evidence that Iranian crocodile enter saltwater. Some part of the area according to importance for diverse fauna and flora, especially bird species, designated as 19th international wetland (Ramsar site) in 1999 Named Govater by & Hur-e-Bahu with an area of 75000 ha. The site consists of riverine and estuarine wetlands of the lower Sarbaz River, including permanent freshwater pools and marshes, mangrove swamps and intertidal mudflats, and also the sandy beach of the adjacent Gulf of Oman coast in the extreme southeast of Iran (Persian Baluchestan) to the border with Pakistan. The distribution are of the crocodiles in the country was supposed to be limited to mentioned areas but further surveys reveals that there are some crocodiles along Nahang River and related water bodies in n north eastern part of Gandou protected area. The river runs along Iran-Pakistan border and finally enters to Pakistan. In the old Persian literatures Nahang has defined as “Crocodile”. The population in Nahang and some parts close to the national border in Gandou area seems to be shared populations with Iran and Pakistan.

The main characteristic of the mugger populations in Iran is that they are very scattered in their range and not limited to only the natural water bodies, even found in the artificial ponds inside the villages. In normal situation and availability of water the crocodiles move between the existing habitats. The population has been divided to several sub-populations along the main rivers and existing habitats. Human activities like construction of dams also have caused forming of sub-populations too. According to the extend of the area and the situation, the relation between sub-populations and also populations of Iran and Pakistan crocodiles seems to be very rare. In Gandou area there are some habitats in border area in which seems that crocodiles move between countries.

The crocodile's habitats

Mugger crocodiles occupy two main “Natural” and “Artificial” habitats in the area and seem that they use all available suitable water bodies.

The main natural habitats are small or large ponds with deep enough water as well as vegetation cover along the rivers. Most of these ponds have similar characteristics providing suitable habitats with very thick vegetation along and sandy banks and some have depth of more than 6-7 meters. Generally, crocodiles avoid from shallow and running parts of the rivers.

Different types of artificial water bodies play essential role as crocodile habitats too. Most of this type is small or large ponds beside or in the villages that are constructed by the people for rain water storage. Dams in different sizes and capacity which are constructed by the people or government are another example for the artificial habitats, in which Pishin dam with more that 170 million m^3 is the most important one in distribution area of crocodiles. The same situation do exists along Kaju River in Zirdan Dam.

Regardless of the negative effects of the dams, it seems that according to the specific situation of the area and prolonged droughts, they play very important role for the crocodile populations by providing reliable habitats.

Main habits

The most specific and important behavior of Mugger is Burrowing. The burrows are used as refuge to avoid heat during hot and or even cold hours of day and may be other purposes. The behavior is observed in different conditions and forms that seem to be related to the habitat. They leave the tunnels at night and wander the area to search for food (Mobaraki 1999). In some occasions two burrows were found close together but not obvious if they are used by one or several specimens (Mobaraki 2002).

In another occasion in Djor pond at the end part of Bahukalat River 5 burrows were observed along an almost dried pond with a length of 200 m. In 2 of the burrows we could observe crocodiles inside and surprisingly could find one hatchling inside one of them, but it remains unclear if it is a kind of care provided by parents or the hatchling itself could find the refugee. Some observed burrows had 1-2 meters length but most were lengthy more than 4 meters. In artificial ponds in the villages burrowing is usual too.

Movement of crocodiles between the habitats is another quite usual recorded behavior in the area. Movement between the habitats seems to be for searching of new habitat. Based on the observations, this behavior seems to be more usual with juvenile crocodiles. But unfortunately this behavior appears to be as threat for the crocodiles as when they have to cross the roads car strike causes death for them. We have recorded several times killed crocodiles in different life stages in the roads (Mobaraki &Abtin 2007). This has been observed on hatchlings to in which a dead hatchling found on the road heading to river on the other side. Considering that most of the crocodile habitats are close to villages, crocodiles pass through the houses in their movements, causing some fear to people. In rainy seasons, as most of the ponds have water, short distance movements of the crocodiles between the ponds are more usual. In Pishin Dam pond which the rocks and stones prevent from digging burrows, the crocodiles use the water leading tunnels as refugee in dry season and lack of water release from reservoir and numbers of tracks are evident inside the tunnels.

Contact with local people

Numerous ponds inside the villages are a potential factor increasing close contact between local people and crocodiles. More over in some parts, most of the villages and human settlements are by or close the rivers and natural pond. This feature explains that all the time local people and crocodiles lived in close relation. It is worthy to explain that all the ponds are visited many times during the day by the people, specially the ladies and children, for daily usages. With so close contact of crocodiles and the local people, the most important factor that prevents from any harm to crocodiles is the cultural and religious believes and respects of the people. In Baluchistan due to water shortage, the crocodiles are respected as water living creature as existing of crocodiles would mean existing of water. Despite of such a close contact, direct Human-crocodile conflict is very rare and the crocodiles attack the people or even swimming children in the ponds. More over, there is not ant exploitation and harvest on crocodiles and the people not only never harm the crocodiles but also prevent the others too. This feature is unique in all crocodile habitats all around the world providing a suitable potential for conservation measures.

But the main problem is that crocodiles usually attack the livestock of the villagers causing economic loss for the people. The number of these attacks according to distribution pattern of crocodiles is considerable which annoys the people. The attacks are sometimes very severe when there is a very large crocodiles in a small pond with small amount of food making the crocodile nuisance. There is compensation program for the people conducted by Department of Environment offices but some times it is not in time and enough. There is a plan to expand the program to provide more support for the people. In some occasions the nuisance crocodiles are removed from the village by DOE guards. In general, the nuisance crocodiles are a potential problem which bothers the local people but in most cases the crocodiles captured and translocate to another habitats which could be safer and in less contact with people.

Number of Muggers in Iran

After years of change in the area caused by drought, flooding and construction of dams along the rivers, and a lack of reliable information on size of the Mugger population, a survey program was conducted over a 10-day period in May 2012. A key feature of the program was that local people, in cooperation with DOE, were engaged directly in the survey activities after training. Crocodiles were counted by direct observation during the day and night. Most available habitats were visited at night, and spotlights used to locate and identify crocodiles.

Potential habitats along the Nahang River were excluded, as well as some remote ponds in the area, due to uncertainty of water availability at the time of survey. Forty-three (43) different survey sections were visited during the survey period, from Firooz Abad pond near Rask and following the Sarbaz and Bahookalat Rivers to Djoor, close to Govatr Bay, as well as the existing artificial ponds and reservoirs in the area. Some parts of the Kajo River were also included. These areas reflected a total survey distance of about 150 km. Except for river mainstreams and ponds associated with them, other important habitats visited were artificial ponds and reservoirs close to villages mainly in "Gando Protected area" (around 465,000 ha).

A total of 326 crocodiles was observed, with Pishin Dam Reservoir (120 crocodiles) and Shirgovaz Regulatory Dam Reservoir (35 crocodiles) reporting the highest counts. Most crocodiles were juveniles or adults, with almost all crocodiles in Pishin Dam Reservoir being of large size (Mobaraki and Abtin 2013).

Main threatening factors

The most effective threats for Mugger crocodiles come from natural threats rather than anthropogenic ones. As mentioned generally there is respect for crocodiles and no one harm or exploits them. But the natural threat of "drought" and Flooding" cause the most important loss for both the crocodiles and their habitats. The periodicity of the factors has not been studied, but from time to time these factors impose some destructions to the crocodile population. Flooding is rarer than the drought and is in in a short period but the drought usually takes long time and we have experience of prolonged drought for 5 years. Hatchlings and juveniles receive the most mortality but even dead adults have been observed. In some occasions flooding destroys most of the nests and lack of water due to drought causes death for most of the hatchlings in one year.

Natural predators like the different species of the reptiles (Bengal monitor lizard) and mammals (Fox, jackal, Mongoose) and large water birds (herons) remain as potential threat for the nests and hatchlings too.

The most evident and may be direct effect of human activities which cause mortality for Muggers is caused by car strike on the roads constructed in the crocodile distribution range (Mobaraki and Abtin 2007). Crocodiles in their movement have to pass the roads and as the most movements re in the night hours, some of them die striking with the cars. Agriculture is the main activity of the local people and its development provides some problems for the crocodile habitats in which development of Banana farms is more effective.

Conservation status

Crocodiles are listed as an “Endangered Species” in Iran and are legally protected. There was a fine of 32 million Rls for illegal killing and capture of a crocodile but the fine increased to 100 million Rls in March 2013. Fortunately there is high potential for the conservation of crocodiles in Iran as the local people respect them as culturally important and never hunt or harm them.

Considering these situation and need for conservation activities "national management plan for the Mugger crocodile population in Iran" prepared and submitted to the related bodies for proper planning and implementation (Mobaraki and Abtin 2008). The budget for the activities is supposed to be secured by DOE and any other international supports would be welcome. The plan consists of 4 main approach and several activities defined for each one which the main items are:

1- Research works and complementary studies
2- Conservation of the crocodiles in the natural habitats
3- Captive breeding
4- public awareness / Education and Ecotourism

In the past years two centers in Dargas and Rikokash have been established for the purposes of rehabilitation, short period keeping of nuisance crocodiles and rearing/reproduction of some crocodiles. There are plans to expand the facilities as farm as well as research center for the crocodiles in the country. Local people are engaged in these centers too. Regular surveys and research works are being conducted all year long on crocodiles and the needed data on their biology and ecology are collected.

References:

1- Mobaraki. Asghar, Elham Abtin, 2007, "Movement Behavior of Muggers" Crocodile specialist group newsletter, Reports from Iran, Vol. 26 No 1, Jan-Mar 2007

2- Mobaraki. Asghar, Elham Abtin, 2013, "Estimate of Mugger population in Iran, Crocodile specialist group newsletter Vol 32, No1, Jan-March2013

3- Mobaraki.Asghar, 2002, "Mugger Crocodile study in Iran "Proceeding of 16th working meeting of the crocodile specialist group, Florida, USA,

4- Mobaraki. A, 1999, A Report on Mugger Feeding in Iran, CSG Newsletter, Vol 18. No 2.Apr-June 9-10.

5- Mobaraki. Asghar, Elham Abtin, 2008, "National Management and Conservation Plan for Mugger Crocodiles" Crocodile specialist group newsletter, Vol. 2 No 3, July-Sep. 2008

Figure 1: Natural habitat of Mugger crocodiles along Sarbaz River

Figure 2: Basking Mugger at the middle part of a natural pond (A.Mobaraki)

Figure 3: Two burrows close to each other in a artificial pond, Djor (A.Mobaraki)

Figure 4: An artificial pond in Djor village

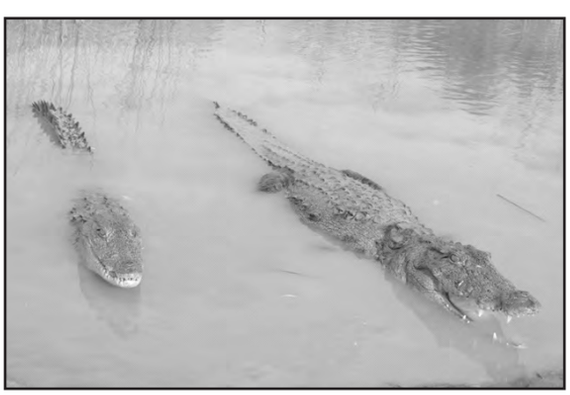

Figure 5: rearing Muggers in Riko Kash center (E.Abtin)

Ecology and conservation of crocodiles in Mesangat Lake, east Kalimantan, Indonesia

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Mesangat Lake in East Kalimantan is home to breeding populations of two crocodilian species: *Tomistoma schlegelii* and *Crocodylus siamensis*. Formerly a forested wetland, the area has been heavily logged since 1970s and further damaged in fires in 1997-98. Several invasive plant species, including *Eicchornia crassipes* and *Salvinia cucullata* now clog up the waterways and the area started undergoing conversion to palm oil plantation in 2008. In 2009 the agricultural development was suspended with an area of 6,000 hectares proposed for conservation. Research surveys focussing on the ecology of endangered species were started, facilitated by local NGOs: initially Yayasan Ulin (Ironwood Foundation) and currently YASIWA (Equator Conservation Foundation Indonesia). The data gathered are being used to implement a long-term conservation management plan for the area and gain more insight into the ecology of *T. schlegelii* and *C. siamensis* in the wild. To date the surveys conducted over three field seasons have provided information on the distribution, range, habitat partitioning and breeding seasons of both crocodile species inhabiting the area. Diet analysis of juvenile *T. schlegelii* and *C. siamensis* revealed no significant differences in their prey choice. Further distribution surveys and nest protection programme involving the local communities in Mesangat will help monitor and manage the species in the area. (Financial support: SSC/CSG Tomistoma Task Force, ZGAP, EAZA, Kölner Zoo, Dortmund Zoo, Virginia Aquarium

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Recent scenario of mugger (*Crocodylus palustris*) population in three districts of Gujarat State, India

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Abstract

A study was carried out in two years (from January 2011 to December 2012) to find out the recent scenario of muggers in the two districts namely Vadodara and Kheda District (now known as Kheda and Anand). These are one of oldest mugger populations in the state. Total 51 water bodies were surveyed in the three districts of Gujarat State, in addition to the 80 km long river stretch of Vishwamitri. Direct sightings of 334 muggers, which include 171 (51%) large and adults (> 2 m), 102 sub-adults (1 to 2 m) and 61 juveniles (<1 m) were recorded from 31 water bodies and the 80 km long river stretch of Vishwamitri. The maximum of 252 muggers were recorded in Vadodara District, followed by 49 in Anand and the least of 33 muggers were noted from Kheda District. However the secondary information and local reports reveal the fact that at least 470 muggers exist in these three districts of the state.

Introduction

The Marsh Crocodile or Mugger (*Crocodylus palustris*) is one of the common, widely spread and most adaptable crocodilian species in India. This species is categorized as nationally 'Vulnerable' subsequent to an assessment following IUCN criteria for threatened species and has the highest legal protection in India as it is listed in Schedule I of the Indian Wildlife (Protection) Act 1972.

During the early seventies, while the Mugger populations in India were reported to decline (FAO, 1974), same trend was recorded in Gujarat State. But whatsoever population survived in the state, was notable as compared to other parts of the country. The few published reports indicated, that the mugger population then was found in four areas namely Sayaji Sarovar (Vadodara District) (Oza, 1975), Gir forest (Junagadh District), Surrounding Barda Hills (Jamnagar District) (Joseph at al, 1978; Whitaker, 1978; Whitaker and Andrews, 2003), and a high density population in a small river stretch of River Sabarmati, near Barsan-Baroda (Kheda District) (Acharya, 1949), in Gujarat. There are few recent publications on the mugger surveys from these three districts (Vijaykumar, 1997), which show few water bodies of Kheda, Anand and Vadodara districts to contain a small number of muggers. Moreover, most recent publications on details of muggers of River Vishwamitri were available too (Vyas, 2010a; 2010b & 2012).

Therefore a study was carried out for two years from January 2011 to December 2012 to find out the recent scenario of muggers in the two districts namely Vadodara and Kheda District (now known as Kheda and Anand). These inhabit one of oldest mugger populations in the state, which survived in the state, after pre-independence and before the declaration of the Indian Wildlife Preservation Act-1972.

Study Area

All the water bodies (WBs) of various sizes from 0.4 sq. km to 20 sq. km of three districts namely Kheda, Anand and Vadodara were explored for the study, including 80 km long river stretch of Vishwamitri and urban sewage pits (**Fig. 1**). The districts; Kheda and Anand (earlier part of Kheda District but after 1998 Anand was separated from Kheda district) are located on south-eastern banks of down streams of River Sabarmati and are well known for their agro produce of crops including tobaccos, pulses, rise and wheat, and large areas irrigated by Mahi Irrigation Project.

Therefore most of the water bodies are interlinked/ connected with irrigation canal network. Vadodara district is situated in between two large perennial Rivers; River Mahi and River Narmada, mainly known for its industrial and agricultural area. A small non perennial river namely River Vishwamitri-Dhadhar flows through the district and transverses the highly populated urban city of Vadodara.

Methodology

All the WBs of three districts was extensively explored to find out the mugger habitats on the basis of direct visual clues and inquiries with locals. These habitats were visited repeatedly in different seasons and the animals were counted as per age groups/ various sizes. The counting methods applied were day count method and night count method (applied only in

specific areas where vast differences were observed in between reports and day count results). The direct sighting and indirect evidences as foot print, feces, egg shells and burrows to mark the presence and absence of the species. During the visits, the habitat was assessed; information about livestock predation by the species, conflict, rescues, translocation and the breeding activity of the species was collected. Additionally, interviews the staff of forest department, wildlife enthusiasts, and local people were carried out, to know the perception of locals towards the species; especially those locals who dwell within a close proximity of WBs. Then the threats were identified, on the species and its habitat, from the study.

Results

Water Bodies Survey: Total 51 water bodies were identified and surveyed, including 15 WBs of Kheda, 16 WBs of Ananad and 20 WBs of Vadodara District, Gujarat State, in addition to the 80 km long river stretch of Vishwamitri which was extensively explored. Of which 10, 9, and 12 WBs of Kheda, Anand and Vadodara, respectively were noted with the presence of the species (Table 1: Appendix1).

Table 1: Water bodies of three districts of Central Gujarat State

Area	No. of Water bodies Surveyed	No. of Water Bodies species
Kheda Dist.	15	10
Anand Dist.	16	09
Vadodara Dist.	20	12
Vishwamitri River	80 km	
Totals	**51**	**31**

Mugger Counts: Total 334 various sized muggers were noted by direct sighting, which includes 171 (51%) large and adults (> 2 m), 102 sub-adults (1 to 2 m) and 61 juveniles (<1 m), recorded from 31 various water bodies and the 80 km long river stretch of Vishwamitri. The maximum of 252 muggers were recorded in Vadodara District, followed by 49 in Anand and the least of 33 muggers noted from Kheda District. However the secondary information and local reports reveal the fact that at least 470 muggers exist in totality in these three districts of the state (**Table 2**).

Table 2: The various sizes of muggers sighted in water bodies of three districts of Central Gujarat State (excluding the 31 muggers reported from Ajwa Sarovar, Vadodara)

Area	No. of WBs with species presence	Number of Muggers Sighted			Total Crocs	Reports
		Juvenile (<1 m)	Sub-Adult (1 to 2 m)	Adult (>2 m)		
Kheda	10	05	11	17	33	072
Anand	09	10	20	19	49	089
Vadodara	12	02	08	12	22	028
Vishwamitri R	80 km	44	63	123	230	250
Totals	**31**	**61**	**102**	**171**	**334**	**439***

Breeding: The breeding activities were recorded in total 11 water bodies by direct and indirect evidences. Empty egg shells, hatchlings and juveniles were recorded at six WBs of Kheda namely; Vaso, Tranj, Tranhaja (canal), Heranj-Chokadiya, Hernaj Gam Talaw and Nagrama. Few nests and hatchlings were recorded at Deva and Malataj village ponds of Anand District. Good breeding performance of the species was observed in year 2012, with few nests on a small river stretch of Vishwamitri, behind the Zoo (2011 & 2012: 1 nest), near Kalaghoda (2 nests: 2012) and in the down streams near Kothavada village (2011 & 2012: 1 nest each years). Nest pit and empty egg shells noted at Kodarvaya and at Chhipwad Ponds situated in the middle of Padra Town in Vadodara District.

Table 3: Number of muggers rescued from the human habitation in Years 2011 and 2012 from three districts of Gujarat State, India

Area	Year 2011	Year 2012	Total
Kheda Dist.	02	2	4
Anand Dist.	03	3	6
Vadodara Dist.	32	29	61
	35	34	71

Rescues, Conflict and Attacks: Most of the mugger population was found in and around human vicinity, hence invariably causing panic and conflicts for the locals. The local NGOs or forest staff provides rescue service for such crocs in conflict. They immediately rush to the location, on call and seize the animal, then releasing it back in nature as per the directions of the local forest officials. Such mugger rescue incidents were observed in all three districts. Total 71 incidents of mugger rescues from human habitation (**Table 3**) were noted, of which 61 cases were recorded from Vadodara, only (**Fig. 2 & 3**). Total 11 croc attacks (9 fatal and 2 non-fatal), including 10 from Vishwamitri-Dhadhar River System, Vadodara District and single from Kheda District were recorded within two years (**Table 4**). Figures also show that of all the Croc attacks, seven incidents on male victims and four attacks on female victims.

Threats: Numerous direct and indirect threats were observed on the species, including water pollution, encroachment on habitat, habitat loss, and river bank development. Very recently three incidences recorded at Vadodara involved dead/killed crocs found on a railway line (a 195 cm long animal) and on the road (a 90 cm long juvenile and an adult 210 cm long). Routes of transport also are a direct threat on the species. Few incidences about poaching and pet trading were also registered as legal cases filed against culprits and poachers.

Conclusion

Total 51 water bodies were surveyed in the three districts of Gujarat State, in addition to the 80 km long river stretch of Vishwamitri. Direct sightings of 334 muggers, which include 171 (51%) large and adults (> 2 m), 102 sub-adults (1 to 2 m) and 61 juveniles (<1 m) were recorded from 31 water bodies and the 80 km long river stretch of Vishwamitri. The maximum of 252 muggers were recorded in Vadodara District, followed by 49 in Anand and the least of 33 muggers were noted from Kheda District. However the secondary information and local reports reveal the fact that at least 470 muggers exist in these three districts of the state. This census indicates that not only has the mugger population flourished, but also has extended its distribution area, much enlarged than that noted in the last census. Earlier records show, there were only 8 and 5 muggers, in the four and three water bodies of Kheda (including Anand District) and Vadodara District, respectively, excluding nine muggers from the River Vishwamitri, upto the city limits. (Vijaykumar, 1997).

The mugger population of River Vishwamitri has increases well in the last two decades (**Figure 4**), especially within the limits of Vadodara City (Vyas, 2010b; 2012). It is also one of the most notable examples and a subject requiring intensive research, of a mugger population surviving and flourishing in an urban sewage. And on the other hand numbers of human-crocodile conflicts have risen in the entire river basin areas, and cannot be ignored or left un-attended.

The overall scenario of mugger population from these three districts; Kheda & Anand and Vadodara was observed distinctly, in terms of the habitat. The crocs of Kheda and Anand survive in fresh water and communal water bodies with rural agricultural landscape, establishing an ideal example of man-animal co-existence. And most of the crocs of Vadodara, especially from River Vishwamitri survive in polluted sewage water, in the core of urban landscape.

The HCC (Human Crocodile Conflict) has increased in last two decades to alarming levels. Past data of crocodile attacks (Vyas, 1998; 2005; 2010a & 2012) recorded from certain parts of Vishwamitri-Dhadhar river system was also accompanied with mitigation measures suggested (Whitaker, 2008). The question that persists is whether these suggestions were accepted and implemented by the authority or not. As a matter of fact, total ten incidences of HCC in the last two years have occurred in the river basin area and eight of these (5 males and 3 females victimized) were fatal. Of the many causes behind HCC, the foremost causes are unavailability of basic facilities for poor people from rural area, large sized of muggers found in human vicinities, lacuna of proper action by forest department and lack of co-ordination between authorities and local NGOs.

There exist several threats on the mugger population, which are generally recorded in even other parts of India, except the direct threat of roadways and railway traffic. This minor threat was earlier recorded in the area (Vyas and Bhavsar, 2009; Vyas, 2012). However, an urgent action plan is needed for the species management. Awareness and education programs are required to avoid the negative impacts which are bound to occur in the minds of laymen. Otherwise our conservation mission might face a failure.

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Table 4: Details of mugger attacks recorded in different parts of study area during years of 2011 to 2013, Gujarat, India

No	Date	Attack	River System	Victim's Sex (Age) /	Activity of the Victim	Location / Details	Geo-coordination	Name of victim / Remarks
1	13 April 2011	Fatal	Vishwamitri	Male (28)	River crossing	Vadsar, Vadodara City	N 22 15' 05.63" E 73 10' 01.30"	Amrut Bhaliya
2	17 April 2011	Fatal	Vishwamitri - Dhhadhar	Female	Washing clothes	Kothawada, Padra	- -	Aminaben Yakub Diwan
3	22 May 2011	Fatal	Vishwamitri - Dhhadhar	Male (15)	River crossing	Kotada, Padra Goraj, Muni Asharam	- -	? -
4	28 May 2011	Non Fatal	Dev River	Female (21)	Washing clothes	Waghodia	N22 20' 02.3" E 73 27' 56.1"	Krishnaba P. Rana
5	6 June 2011	Fatal	Dhhadhar	Male (45)	Sand collection	Virjay Village, Padra	N22° 5'25.61" E72°59'48.15"	-
6	21 Aug. 2011	Fatal	Vishwamitri	Male (22)	River crossing	Khalipur, Vadodara	N22°12'24.30" E73° 9'34.63"	Navin Narnbhai Rathodiya
7	29th Sep 2011	Fatal	Dev River	Male (52)	Bathing	Nr. Goraj, Waghodia Muni Asharm,	N22 20' 01.95" E 73 27' 56.45"	Dilip J. Joshi
8	8th Oct. 2011	Non Fatal	Vishwamitri	Male(40)	Bathing	Near Sama bridge, Vadodara City	N22°20'17.46" E73°12'17.44"	Ravaji J. Mali Leg cached
10	29 sep 2012	Fatal	Village Pond	Female (17)	Washing	Kodar-vaya, Jarod, Waghodia	N22 25' 20.41 E73 23' 8.68"	Koushalya k. Vasava
11	25 Oct. 2012	Fatal	Dev River	Female (11)	Washing clothes	Nr. Goraj village, Waghodia	N22 20 07.52 E73 28' 58.46"	Tejal C. Parmar
12	3rd March 2012	Non Fatal	Village pond	Male (10)	Watching animals	Traj, Matar, Kheda	N22°40'19.60" E72°38'34.23"	Jaimin J. Parmar,

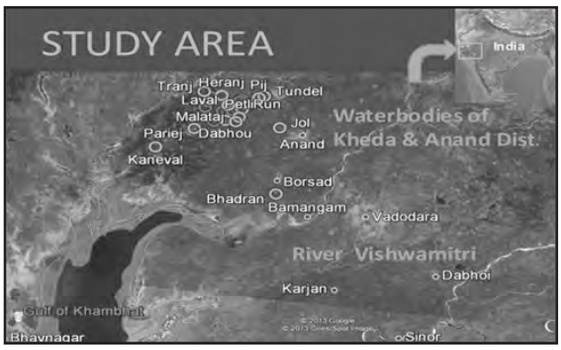

Figure 1: Map of study area showing locations of River Vishwamitri and water bodies of Kheda, Anand and Vadodara Districts of Gujarat, India (Courtesy Google earth).

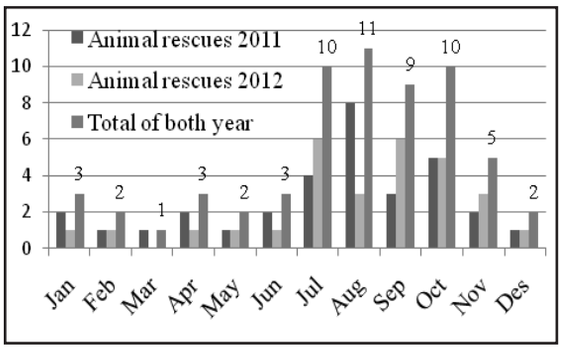

Figure 2: Pictograph showing rescued Muggers in various months from Vadodara City, Gujarat, India

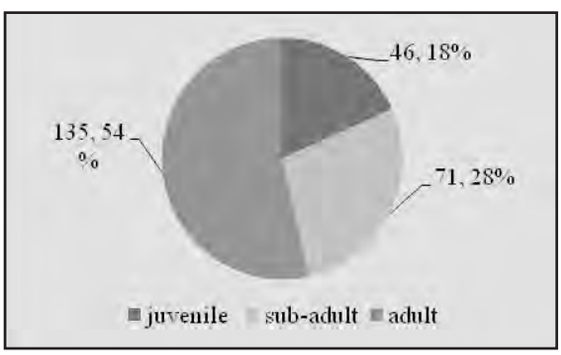

Figure 3: The pie-chart showing various sized muggers rescued from Vadodara City, during last two years.

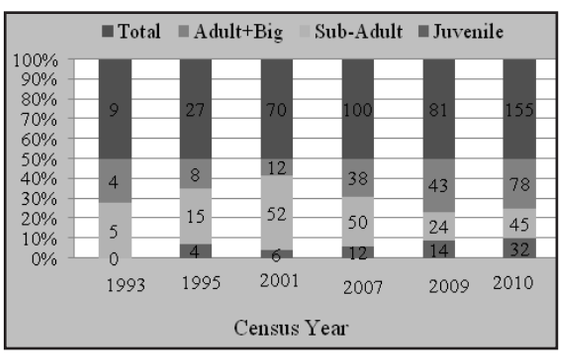

Figure 4: The pictograph of mugger population data of last two decades from River Vishwamitri within the city limit.

References

01. Acharya, H. N. (1949). List of reptiles from Gujarat state, *Prakurti* 8:156-178. (In Gujarati).

02. FAO (1974). India- a preliminary survey of the prospects for crocodile farming, UNDP/FAO, FOIND/71/033. 66pp.

03. Joseph, A., E. Chauhan, K. Khanna and Whitaker, R. (1975). Marsh crocodile *Crocodylus palustris* in the Gir. *J. Bombay Natural History Society* 72(3):862-863.

04. Oza, G. M. (1975). Conservation of the crocodile in the Sayaji Sarovar lake, Baroda, *India. Bio. Conservation*. 7: 235- 236.

05. Vijaykumar, V. (1997). Evaluation of restocked mugger crocodiles and its implication in long-term conservation and management of the species in Gujarat, India, Gujarat Institute of Desert Ecology, Bhuj-Kachh, Gujarat, 65 pp. (Unpublished Report).

06. Vijaya Kumar, V., R. Vyas and Choudhury, B.C. (1999). Status of mugger in Gujarat State. *CSG Newsletter*. 18(2): 7-8.

07. Vijaya Kumar, V., R. Vyas and Choudhury, B.C. (1999). Status of mugger and its conservation problems in Gujarat. *ENVIS* (Wildlife & Protected Area) Vol. 2; No. 1; Wildlife Institute of India, DehraDun; June 1999: 69-76.

08. Vyas, R. (1993). Recent cases of man-eating by the Mugger (*Crocodylus pulustris*) in Gujarat state. *Hamadryad*. 18 :48-49.

09. Vyas, R. (2005). Recent notable incidences of conflict between mugger and humans in Gujarat. *CSG Newsletter* 24(2): 7 8.

10. Vyas, R. (2010). The Muggers (*Crocodylus palustris*) of Vishwamitri River: Past and Present. Herpetology & Environmental Research Project (HERP), Vadodara, Gujarat State, March 2010: 32pp+ Fig.5+Table 11+ i-xxi. (Published Report)

11. Vyas, R. (2010). Mugger (C*rocodylus palustris*) population in and around Vadodara City, Gujarat State, India. *Russian Journal of Herpetology* 17(1): 43-50.

12. Vyas, R. (2012). Current status of Marsh Crocodiles *Crocodylus palustris* (Reptilia: Crocodylidae) in Vishwamitri River, Vadodara City, Gujarat, India. *J. of Threatened Taxa* 4 (14):3333-3341.

13. *Vyas, R. and Bhavsar, S.R. (*2009). Movement of an individual mugger into urban areas of Vadodara City, Gujarat state, India. *CSG Newsletter 28(3): 5-7. ().*

14. Whitaker N. (2008). Survey of human-crocodile conflict in Gujarat and Rajasthan: Trial of conflict mitigation education materials and further information on conflicts, UNDP/GEF/ SGP Project, Madras Crocodile Bank, 30pp. (Unpublished Report).

15. Whitaker, R. (1977). Notes on the status of Gir crocodiles, *J. Bombay Natural History Society* 75(1):224-227.

16. Whitaker, R. and Andrews, H.V. (2003). Crocodile conservation, Western Asia region: An update. *J. Bombay natural History Society* 100 (2& 3): 432-445.

Appendix 1: Details of Water bodies of Kheda, District, Central Gujarat, India

No	Water body	Go-coordination	Area of WB	Juvenile	Sub-Adult	Adult	Total Sightings	Muggers reported	Use of WB
1	Dundel, Nadiyad	22°40'34.36"N 72°49'15.11"E	1.0	0	0	0	0	0	Common usual Fish Farming
2	Pij Kapil, Nadiyad (2WB)	22°40'8.00"N 72°48'25.61"E	1+1=2	0	0	0	0	2	Common usual
3	Vaso Talaw, Nadiyad	22°39'24.32"N 72°45'21.28"E	1.0	0	1	1	2	5	Common usual
4	Ramsarovar, Vaso, Nadiyad	22°39'3.16"N 72°45'3.37"E	1.0	0	0	0	0	3	Common usual
5	Gangapur, Nadiyad (2WB)	22°38'36.59"N 72°46'38.42"E	0.4+0.6 = 1.0	0	2	0	2	3	Common usual
6	Tranj, Matar	22°40'19.60"N 72°38'34.23"E	2.8	0	0	2	2	16	Common usual Fish Farming
7	Pariej, Matar	22°32'44.51"N 72°37'0.43"E	9.0	1	2	3	6	6	Reserved Irrigation WB
8	Nr. Kans, Tranhaja, Matar	22°38'20.23"N 72°39'31.76"E	2.9	0	0	2	2	5	Common usual
9	Heranj-Chokdiya, Matar	22°40'0.25"N 72°41'39.10"E	3.6	1	2	3	6	12	Common usual Fish Farming
10	Heranj, Gam Talav	22°39'38.37"N 72°41'41.60"E	1.2	1	1	1	3	4	Common usual
11	Nagrama	22°37'4.49"N 72°38'59.66"E	4.5	2	2	5	9	15	Common usual Fish Farming
12	Machhiel	22°39'26.17"N 72°40'5.41"E	0.9	0	1	0	1	2	Common usual Fish Farming
			Total	**5**	**11**	**17**	**33**	**72**	
		Details of Water bodies of Anand District, Central Gujarat, India							
1	Deva-vant, Sojitra (3WB	22°37'13.36"N 72°44'5.91"E	1+1.1+ 1.2=3.3	9	11	10	4+14+2= 30	40	Common usual Fish Farming
2	Malataj, Sojitra	22°34'53.58"N 72°44'58.61"E	1.25	z1	2	3	6	30	Common usual
3	Dabhou, Sojitra Twin WB	22°35'2.20"N 72°43'4.47"E	1.7	0	1	0	1	2	Common usual Fish Farming
4	Petali, Sojitara	22°35'55.11"N 72°45'25.61"E	0.5	0	0	1	1	2	Common usual
5	Run, Sojitara	22°37'37.72"N 22°37'37.72"N	0.5	0	0	0	0	1	Common usual
6	Laval-Deva, Sojitara	22°38'10.07"N 72°43'7.26"E	1.1	0	2	2	4	4	Common usual
7	Bhadkat Deva, Sojitara	22°36'47.54"N 72°42'16.22"E	0.9	0	0	0	0	1	Common usual
8	Sejava-Deva Sojitara	--		0	0	0	0	1	Common usual

9	Maghrol, Sojitra	22°34'32"N 72°40'56"E	1.5	0	2	1	3	3	Common usual
10	Jol, Anand	22°34'35.20"N 72°53'0.88"E	0.6	0	1	1	2	2	Common usual
11	Kaneval, Tarapur	22°27'52.28"N 72°31'12.87"E	9.7	0	0	1	1	2	Reserved Irrigation WB
12	Bhadran, Borsad	22°21'9.81"N 72°54'8.27"E	0.5	0	1	0	1	1	Common usual Fish Farming
			Totals	**10**	**20**	**19**	**49**	**89**	

Appendix 1 Continue: Details of Water bodies of Vadodara District, Central Gujarat, India

No	Water body	Go-coordination	Area of WB	Juvenile	Sub-Adult	Adult	Total Sightings	Muggers reported	Use of WB
1	Opp. Talaw, Sarnej, Savli	22°29'2.95"N 73°24'39.42"E	1	0	0	3	3	4	Fish Farming
	Talaw, Sarnej, Savli	22°29'10.47"N 73°25'0.58"E	1	0	1	0	1	3	Fish Farming
2	Talaw Rajpura Savali	22°29'41.78"N 73°25'4.37"E	1	0	0	1	1	4	Fish Farming
3	Ajawa, Vaghodia	22°23'11.0" N 73° 23' 00.8"E	19.0	0	0	0	?	Not Surveyed	Potable Water Illegal Fishing
4	Kodarvaya, Vaghodia	22°25'24.22"N 73°23'10.93"E	1.5	0	1	3	4	4	Common usual Fish Farming
5	Karmasiya, Vaghodia	22°24'42.10"N 73°24'49.13"E	0.6	0	0	1	1	2	Common usual
6	Kamlapura Vaghodia	22°25'2.76"N 73°23'57.96"E	1.1	1	0	0	1	-	Common usual
7	Sim,KamlapurVaghodia	22°25'13.64"N 73°24'25.49"E	0.8	0	1	0	1	-	Common usual
8	Timbi, Vaghodia	22°18'52.88"N 73°17'11.80"E	7.0	0	1	0	1	-	Common usual Irrigation
9	Padra Town, Padra	22°14'11.33"N 73° 5'12.55"E	0.7	1	1	1	3	4	Common usual
10	Sim Talaw, Ghayaj, Padra	22°12'48.85"N 73° 5'49.99"E	0.7	0	1	3	4	4	Sewage Pond
11	Masar, Padra	22° 7'12.42"N 72°54'34.22"E	1.1	0	1	0	1	-	Common usual
12	Vadadala, Savali	22°28'30.82"N 73°18'52.95"E	5	0	1	0	1	3	Common usual Fish Farming

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pp 227 - 233

Crocodile attacks in Sri Lanka

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Abstract

Sri Lankans living in rural and some urban areas risk attack by venomous snakes, elephants, buffaloes, bears and crocodiles. Some of these instances of human-animal conflict culminate in hospitalization with minor to severe injury, some are left with permanent disability of varying degrees and some result in fatality. A total of 177 cases of crocodile attacks by the mugger (*Crocodylus palustris*) and the saltwater crocodile (*Crocodylus porosus*) were investigated. Of the 177 attacks 148 (84%) of the victims were male, 27 (15%) were female and in 2 cases the gender was not recorded. The circumstances of the attacks were that 113 (64%) of the cases happened while the victim was bathing/washing, 38 (22%) while fishing and the rest during other miscellaneous activities. In the present investigation 50 (28%) of the cases were fatal and in 7 of these cases the body was not recovered. As a preventive measure against human-crocodile conflict (HCC) many techniques have been employed. Of these the traditional crocodile excluding enclosure (CEE's) has been used in the country for over 100 years and is recommended as a means for protecting both humans and crocodiles.

Introduction

Most Sri Lankans living in rural areas risk attacks by venomous snakes, elephants, buffaloes, bears and crocodiles. Some of these incidents of human-animal conflict culminate in hospitalization with minor to severe injuries, some are left with disabilities of varying degrees and some culminate fatally. As regards snakebite earlier studies indicated that approximately 65,000 people were being bitten by snakes annually, of which around 600 died (de Silva, 1976; de Silva and Ranasinghe, 1983). The present number of fatalities due to snakebite envenoming has reduced due to management of snakebite patients with antivenom serum. More recent official hospital reports indicate around 60 deaths for the year 2008, however, if we include an estimate for cases that have not been reported or not reached the medical statistician, we can assume that about 100 people die annually due to snakebite. Human-elephant conflict currently results in approximately 50 human deaths and 150 elephant deaths annually. Although during the past decade an average of only 2 deaths per year have occurred due to crocodile attacks these receive considerable media publicity.

Conflict between humans and crocodiles is probably as old as the human race and the fossil record shows that our ancestors were being attacked over one million years ago. The National Geographic News published on February 25, 2010 reported on fossil evidence of hominid bones with crocodile bite marks. These bones had been discovered in 2007 in Tanzania's fossil-rich Olduvai Gorge, a site that was home to early humans and to the 1.84-million-year-old crocodile species, dubbed *Crocodylus anthropophagus*, which means "eater of humans" in Latin. The oldest human skeletons discovered during archaeological excavations in Sri Lanka are around 37,000 YBP. These have not been investigated to see whether there are any crocodile bite marks present. However, there are several ancient traditional medical works in the country that include medicaments for crocodile bite. Perhaps, one of the first to include such medicaments is the *Sārārtha Sangrahaya,* written by the physician King Buddhadāsa around 337-365 AC (de Silva and Uragoda, 1983). It records the application of a mixture of three kinds of ginger onto crocodile bite wounds. Additionally, there are also impressive historical reports of crocodile attacks in the country. The Great Chronicle of Sri Lanka, the *Mahāvamsa* (recent part is known as *Cūlavamsa* (1:70.4) records the presence of large populations of crocodiles as well as the fact that people knew of fatal crocodile attacks. It also records that the army of King Parakkramabahu (1153-1186 AC) could not pass the deep waters at Yatthikanda and Dumbara due to man-eating crocodiles (Geiger, 1929). Wickramasinghe (2001) records that during the reign of King Rajasinghe the 2nd (1629-1687 AC) there had been many crocodile attacks around Gal-Oya. The king himself took his royal spear and thrust it into a man-eater in that river, and the crocodile submerged with the spear. Seeing this, one of his generals dived into the water, killed the crocodile and brought back the king's spear for which bravery he was rewarded immensely (Wickramasinghe, 2001). Additionally, we see that many Europeans who visited Sri Lanka over the past few centuries and who wrote about the country included some accounts of the reptiles, especially the snakes and crocodiles, in their works. The following are a few accounts of crocodile attacks recorded in these publications, which indicate that HCC has been occurring in the country for several centuries. These references are listed chronologically:

- Saar (1672) records the abundance of man-eating crocodiles he encountered in Negombo.
- Baker (1853) reports of accounts of crocodiles attacking animals and humans

- Le Bruin (cited in Suckling 1876) tells of a crocodile that had devoured at least 32 people at different times.
- Clark (1901) states that every year a number of men, women and children are killed by crocodiles.
- Julius (1907) reports that many native women have been seized when coming to draw water, and dragged down and eaten by crocodiles.
- Haughton (1916) reports of shooting two specimens measuring 5.57 m and 5.62 m in length at Kantali reservoir (Eastern Province). Until 1928 it had been dangerous for boatmen to dangle their limbs in the water of this reservoir as crocodiles had accounted for a number of human lives.
- An anonymous reporter (1924a) relates that at Hikkaduwa a 10 feet 8 inches long crocodile had attacked and eaten several humans. Another anonymous reporter (1924b) tells of a different man-eater at Hikkaduwa that was fifteen feet long and had attacked humans and cattle and been subsequently shot.
- Deraniyagala (1939) reports that the Government Agent of the Southern Province had informed him that a crocodile at Palatuva, Matara in Nilwala River had killed between 10-12 humans over a period of 20 years. It had been shot on 14th June, 1927. It is of interest to note that when the present author conducted his first survey of the Nilwala River in 2008 there were still some recent fatal crocodile attacks reported from Palatuva (de Silva, 2008). Furthermore, Deraniyagala (1939) also reports that the Government Agent of the Eastern Province had informed him that between 1900 and 1925, fifty-three humans had been devoured by crocodiles in Batticoloa district and nine in Trincomalee.

The above are just a few examples from a vast array of past literature on crocodile attacks in the country, indicating the severity of the HCC problem. If we take a rough calculation of the number of crocodile attacks that had been reported from Julius (1907) to Deraniyagala (1939), it is possible to estimate that approximately 150 humans could have died from crocodile attacks in the country during a period of approximately 30 years. During this period most aquatic systems of the country had large populations of both species of crocodile and this was before the large scale hunting of crocodiles for the skin trade.

Methods

Information on crocodile attacks was collected from the grass-root level government officers known as Grama Niladhari (= village headmen) as they are informed of any sudden deaths, from local police stations, field contacts, hospitals and information from printed media. Localities were visited and information regarding the attack was recorded on a structured survey form either from accounts given by the victim's family or friends, or if alive direct from the victim. In most cases, the exact place on the particular watercourse where the incident took place was visited, a GPS reading recorded and photographs of the location taken. Photographs of the injuries sustained by living victims and, in a few cases, of the dead person were taken where permission was granted. We noted that the best source of information on other crocodile attack victims was from people who had been attacked by crocodiles themselves. A preliminary survey was conducted on the human-crocodile conflict (HCC) in Matara in 2008. Subsequently an island-wide survey was conducted from 2009 to March 2013. During the survey, we also received information of 21 cases of crocodile attacks which took place between 10 and 29 years ago.

Survey findings

The case histories of 177 people from various parts of the island who had been attacked by crocodile in the last ten years were collected. Of these, 146 (83%) attacks were by the mugger (*Crocodylus palustris*) and 31 (18%) by the saltwater crocodile (*Crocodylus porosus*). Details of these crocodile attacks are given below. In the present study, 50 (28%) of the cases ended fatally, and in 7 (4%) cases the body was not recovered although people had witnessed these attacks and seen the crocodile taking away the victim.

Pattern of crocodile attacks

Brief details of the pattern of crocodile attacks are given below:

Gender of the victims: Of the 177 victims, 148 (84%) were male and 27 (15%) were female. The gender of 2 cases was missing from the record.

Occupation of the crocodile attack victims: The occupation of 120 victims out of the total 177 crocodile victims was recorded and indicates: 38 (32 %) fishermen; 49 (41 %) farmer / labourers; 6 (5 %) housewives; 21 (18 %) children and 6 (5 %) others. In the last category there was one captain of the armed services.

Activity of the victim during the crocodile attack: A majority 113 (64%) were attacked by crocodiles while bathing/washing (Figure 1). This was followed by fishing 38 (22%) (Figure 2). The rest were grouped as miscellaneous activities, as people living along rivers and streams and in the vicinity of tanks, rivers, marshes depend on these water bodies for their domestic needs e.g. drinking, and livelihoods like harvesting aquatic or semi-aquatic edible and non-edible plants.

Did the victim shout for help: Of 73 records, 49 victims shouted for help.

Status of the victim when attacked: Of 88 records, 38 victims were alone when the crocodile attacked, and in 50 cases the victims were either with a companion or with a child.

Was the victim aware of the existence of crocodiles even before the attack: Of 104 victims who responded 94 (90%) knew beforehand of the presence of crocodiles in the particular water source they were using.

Did the victim use the same place, undertake the same activity and at the same time: Of 124 people who responded 80 (65 %) had been using the same spot at the same time to carry out the same activity (bathing or washing etc) over a period.

Type of treatment sought after attack: Of the 101 victims who answered this question, 89 (88 %) had sought western treatment, whereas only 12 victims reported seeking traditional medicine. However, we observed that many yet seek and practice religious and sorcery in case of crocodile attacks.

Was the particular crocodile killed after the attack: Of 81 responses, 37 % stated that they believed the offending crocodile had been killed.

Crocodile attacks on farm and pet animals: In addition to humans we were informed that cattle (25 cases) and dogs (12 cases) had been taken by crocodiles.

Conclusion and recommendations

Data of 177 cases of crocodile attacks have been collected by the authors. However, based upon information received from various parts of the island, there were other crocodile victims that we could not investigate due to lack of time and the difficulty in visiting remote villages. As regards the offending species, 146 (83%) were by mugger crocodiles (*Crocodylus palustris*). This high percentage could be due to the fact that the mugger is widely distributed across virtually the entire dry zone plains in rivers, streams as well as in man-made aquatic ecosystems, such as the 10,000 odd tanks or reservoirs, agricultural canals, agro-wells and streams. All these aquatic ecosystems are widely and daily used by the people living in the dry zone plains for their everyday needs as well as for agriculture, plantations and for farm animals (Figure 1, 2). Additionally, with the exponential increase of human populations due to large-scale agricultural and human settlement projects over the past half century, the number of humans and livestock using natural water bodies in the dry zone of Sri Lanka has increased significantly. Water bodies in these areas are also inhabited by mugger crocodiles (*Crocodylus palustris*), the top predators of the ecosystem. This sharing of an essential, but a limited resource has resulted in an increase of HCC (Somaweera and de Silva, 2013). Furthermore, the traditional crocodile excluding enclosures are not used in the dry zone. Thus, it is natural there will be more mugger attacks when compared to the saltwater crocodile (*Crocodylus porosus*) attacks which numbered 31 (18%). It is, however, possible that there are more saltwater crocodile attacks which we have not investigated.

When considering these statistics we should note that in 2010 an approximate population of 1500 to 2500 mugger crocodiles was estimated to exist in Sri Lanka (de Silva and Lenin, 2010). More recently during the CSG Red Listing sessions conducted by James Perran Ross, during the 22nd Working Meeting held in Sri Lanka (May, 21-23, 2013) a population of 3500 wild mugger was arrived at by the assessors. This discrepancy can be explained as being due to several locations with healthy mugger populations being included in the new data that were not included in the previous estimates. In the present study, 50 (28%) attacks ended fatally. When these bodies were recovered after between a few hours to 1 or 2 days later, many parts of the body were missing. It was evident that the offending crocodile or crocodiles had devoured parts of the body rather than being eaten by fish or terrapins. In the present study the body of 7 (4%) victims was not recovered, although people had witnessed the victim being attacked and dragged away by a crocodile. In these cases the family, relations, friends and villagers joined in the search for the body, together with other relevant authorities (like police, Dept of Wildlife Conservation and NGO's) but without success.

The Male:Female ratio of crocodile victims in the present study was 6:1. A majority 113 (64%) were attacked by crocodiles while bathing/washing. This was followed by fishing 38 (22%). This result contrasts with a HCC study in Zambia where of 127 crocodile attacks in the Chiawa Game Management Area Zambia, 63% were fatal and the majority of attacks (54%) targeted fishermen as they fished from canoes (Wallace, 2010). Here it should be noted that freshwater fishery industry in Sri Lanka is increasing and has caused a major threat to the crocodiles of the country. The authors came across several incidents where the crocodiles which got entangled in fish nets were killed. The other circumstances where people got attacked were grouped as miscellaneous activities, as people living along rivers and streams and in the vicinity of tanks, rivers, marshes depend on these water bodies for their domestic needs e.g. drinking, bathing, washing and livelihoods like harvesting aquatic or semi-aquatic edible and non-edible plants.

Two significant finding of the study were:

1. That of 104 victims who responded 94 (90%) knew beforehand of the presence of crocodiles in the particular water source they were using. In fact some stated that their parents and grand parent knew of the

presence of crocodiles in the particular watercourse.

2. Of 124 people who responded 80 (65 %) had been using the same spot in the river/tank/stream at the same time to carry out the same activity like bathing or washing etc over a period of time.

Although the majority (90%) of the victims were aware of the presence of crocodiles in the particular aquatic habitat before they were attacked, all used words such as “I used to see it on the opposite bank”, or 'it was minding its own business' or “I never expected it to attack me”. Also several victims informed us that the crocodile had watched them for several weeks. This suggests that the people were not aware of the behaviour of crocodiles and had underestimated their intelligence. It is now well known that crocodiles follow the behavior and movements of the prey (human or animal) it is targeting for days before attacking. Another vital fact that emerged from the accounts related by crocodile attack victims and witnesses, was that they were repeating the same act (bathing, washing, fishing etc) at the same place and same time. Furthermore, of 88 records, 38 victims were alone when the crocodile attacked, and in 50 cases the victims were either with a companion or with a child. This indicates that the crocodile will target if the victim is alone or with one companion and not when there are several people bathing and splashing water and shouting.

During our survey we also observed and were informed that farm animals such as cattle, buffalo, goat and dogs regularly used the same spot for drinking and that these animals attracted crocodiles. The present study showed that the legs 45 (47%) of victims were the most vulnerable body part the crocodile attacked (Figures 3, 4), followed by the arms, 25 (19%) (Figures 5, 6). There were four cases where the buttocks were attacked (Figure 7) and in 12 cases the trunk including the chest was attacked (Figure 8).

When inquired whether the crocodile dragged the victim, ninety-eight (93%) victims stated that they were dragged into the water by the crocodile. One lady (43 years old) who sustained grievous injuries in the upper thigh had been dragged about 50 m away from the place she was bathing. When the crocodile attacked 67% of the victims had shouted for help while been dragged, perhaps the other could not shout for help as they would have been shocked or chocked with water.

Prevention of crocodile attacks

There is evidence from Sri Lanka to show that vulnerable people living close to crocodile habitats have taken various steps to protect themselves from crocodile attacks (de Silva, 2011, 2013). These traditional methods are:

1. Use of 'Crocodile Repellents' whereby herbal mixtures are put into the water. When the mixture disperses it is supposed to deter crocodiles from coming into that water (de Alwis, 1948; de Silva, 2011, 2013). At the present time experimental work on this herbal mixture is in progress.
2. Charms or an occult practice is believed to afford protection from crocodile attacks when recited in the prescribed fashion (Gnanaloka, 1954; de Silva, 2011, 2013). These forms of protection are now seldom used. Crocodile charmers are still popular in Borneo where man-eating crocodiles are common (Ritchie and Jong, 2002). It is of interest to note here that in the pearl fisheries of the early British period, the government had engaged the services of 'shark charmers' to protect the divers harvesting pearl oysters from shark attacks (Cordiner, 1807; Tennent, 1861).
3. Another well known protective method perhaps used from the 15th century AC is the crocodile t**alisman, where a g**ranite stone is engraved with charms and a talisman is placed in the water where people and farm animals frequent (Figure) (de Silva, 2010, 2013; Rohandheera, 2007).
4. People living along the Nilwala River in Matara which has been known for several centuries as a hotspot for saltwater crocodile attacks have been using highly practical and safe physical barriers**:** Crocodile Exclusion Enclosures (CEE). These enclosures are known in Sri Lanka as '*kimbul kotuwa'* (in Sinhala *kimbul* = crocodile and *kotuwa* = enclosure or pen). Traditional crocodile exclusion enclosures are constructed of thick kitul palm (*Caryota urens*) planks or long hard wooden poles firmly driven into the river bed, the two ends of the enclosure abutting the banks (Figure). In the recent past (2007), enclosures have been fashioned using metal rods and wire mesh (Figures) (de Silva, 2008, 2011, 2013). Additionally the Disaster Management unit of Matara has already installed 30 odd metal CEE's along the Nilwala river and some tributaries of it.

Though the effectiveness of the simple traditional crocodile excluding enclosure (CEE's) has been shown (de Silva, 2010, 2011; Somaweera and de Silva, 2013) all attacks took place where there was no CEE earlier, but the worse was, the few recent fatal cases (2011, 2012 and 2013) the victims have been bathing just few meters away from the CEE. This indicates the shear carelessness of the people. The recent (2012) fatal case of an 18 year old girl attracted wide media coverage as apparently the personal CEE they had installed had several wooden poles missing for some time and the crocodile entered through the gap and attacked and killed the girl.

All traditional and the newer metal enclosures studied had only 3 sides fenced, being open to the bank. In a previous report, the author has recommended that an ideal CEE should be fenced on all four sides, with an entrance door from the land side that should be kept closed when the enclosure is not in use (de Silva, 2008). This is to prevent crocodiles that wander about on land at night accidentally entering the enclosure and remaining inside the CEE's. We came across 2 incidents (Tissamaharama and Matara) where a crocodile had come into a three-sided CEE (de Silva, 2008; Somaweera and de Silva, 2013).

There are two other preventive methods adopted in recent times - Crocodile excluding fences (CEF) and the installation of warning signboards. The CEF is installed at places where crocodiles stray into domestic compounds in the night, usually to attack pet animals or poultry. This has resulted in the construction of "crocodile fences" made of metal to protect domestic property (de Silva, 2008). Drawing attention to dangers by means of warnings on signboards would be a simple and important step in any preventive strategy. However, it has been observed that warning signboards are not generally displayed, even at the many tanks and rivers where several crocodile attacks have taken place in the past.

Killing and Translocation

During our survey we received reliable information that several crocodiles have been killed after attacks by the family, friends and villagers. In one instance, after a 5 year old boy was killed the father and his friends have killed approximately 5 crocodiles inhabiting that particular stream. In Matara, Nilwala River some villagers have put poisoned baits and approximately several crocodiles have been seen floating in the river few days later. The Department of Wildlife Conservation has translocated several saltwater crocodiles (mainly from Nilwala River) over the past decade. These have been released in National Parks belonging to the department; however, these are mainly mugger habitats.

Recommendations

As a result of our island-wide survey of selected habitats of mugger (*Crocodylus palustris*) and saltwater crocodile (*Crocodylus porosus*) together with inquiries into incidents of attacks on humans at these locations, several important and interesting observations have emerged. These need to be taken into account for future planning and for conducting awareness programs. According to the accounts of crocodile attack victims and witnesses, it appears that crocodiles have observed people engaged in their water-based activity, like bathing and washing clothes, over a period of time before an attack. This would imply that, at least some attacks, were not the result of a casual encounter with potential prey, but the culmination of a hunt at a spot where prey was known to gather. Based on our findings the following actions should be progressed:

1. Intensive awareness programmes among vulnerable populations. Inform them if possible not use the same place, same time and same action, if possible, if not to take extra precautions. If a crocodile is observed around the place where they bathe/wash they should not underestimate its intelligence - it is possible that it is planning to attack.
2. Installation and maintenance of physical protective structures such as 'crocodile exclusion enclosures' (CEE) and 'crocodile-fences'; and
3. Installation of warning sign boards in danger prone areas.
4. Educate as to the importance of crocodiles in our aquatic ecosystems
5. Killing or translocation of offending crocodiles is questionable as shooting or capturing any specific 'man-eater' is questionable. Australian studies (Caldidicott et al., 2005) indicate that there is no guarantee that the crocodile responsible for the attack can be captured. In addition, incidents of translocation of supposed 'man-eaters' into wildlife sanctuaries is known in the country (N. Atapattu, personal communication, 2008). However, the 'homing' capability of crocodiles is now well known (Read et. 2007). In this case perhaps the best is to install a CEE or keep the animal in a zoo or a crocodile farm.

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Literature cited

1. Anonymous. 1924a. The man - eater of Hikkaduwa *Times of Ceylon Sunday Illustrated*. 3(8): 542

2. Anonymous. 1924b. Another man - eater of Hikkaduwa. *Times of Ceylon Sunday Illustrated*. 3(13): 796.

3. Baker, S. W. 1970. *The rifle and the hound in Ceylon*. Tisara Prakasakayo, Dehiwala. (1st Edition 1853)

4. Clark, Alfred. 1901. Crocodiles IN: *Sport in the low-country of Ceylon.* Reprint Tisara Prakasakayo, Dehiwala. 1971. pp 64-68.

5. Caldicott, D. G. E., D. Croser, C. Manolis, G. Webb & A. Britton. 2005. Crocodile attacks in Australia. *Crocodile Specialists Group Newsletter*. 24(4): 18.

6. Cordiner, Rev. J. 1807. *A description of Ceylon*. Tisara Prakasakayo Ltd., Dehwala (Reprinted in 1983). Pp 504.

7. De Alwis, I. A. D. A. 1948. *Watika Prakaranaya hewath, Beheth guli kalka potha*, M D Gunasena Colombo, pp. 463-467.

8. de Silva, Anslem. 1976. The Pattern of Snakebite in Sri Lanka, The Snake 8(1): 43-51

9. de Silva, Anslem. 2008. The status of the Saltwater crocodile (Crocodylus porosus) inhabiting the Nilwala River, Matara District and its impact on the community. IUCN/WWF/American Red Cross Partnership. 34 pages.

10. de Silva, Anslem. 2010. *Crocodiles of Sri Lanka: Preliminary Assessment of their Status and the Human Crocodile Conflict Situation*. Mohamed Bin Zeyed Species Conservation Fund. Printed at AMP Print Shop, Gampola. 49 p.

11. de Silva, Anslem. 2011. Prevention of crocodile attacks in Sri Lanka: some traditional methods. *Crocodile Specialist Group Newsletter*. 30(1): 28-31

12. de Silva, Anslem. 2012, Crocodile Psychosis. IN: *Proceedings of the Conference on Herpetological Conservation and Biology*. Postgraduate of Science, University of Peradeniya, Nov. 28-29, 2012. p. 5

13. de Silva, Anslem & J. Lenin. 2010. Mugger Crocodile Crocodylus palustris. Pp. 94-98 in *Crocodiles*. Status Survey and Conservation Action Plan. Third Edition, ed. by S.C. Manolis and C. Stevenson. Crocodile Specialist Group: Darwin).

14. de Silva, Anslem. & L. Ranasinghe. 1983. Epidemiology of snake-bite in Sri Lanka : A review, *Ceylon Medical Journal,* 28(3): 144-154

15. de Silva, Anslem & GC, Uragoda. 1983. Traditional methods of snake-bite treatment in Sri Lanka, *Ceylon Medical Journal,* 28(3): 170-174

16. Deraniyagala, P E P. 1939. *The Tetrapod reptiles of Ceylon*. Vol.1 Testudinates and crocodilians. National Museum, + 412

17. Geiger, W. 1929. *Culavamsa* Part 1. Pali Test Society, Oxford University Press, UK. 362 p.

18. Gnanaloka, Rev. N. 1954. *Mantra Shathakaya*. D.H. Jayasekara, Matara Merchants lt. Press: Matara. (Text in Sinhalese).

19. Haughton, S. 1916. *Sport and Travel*, University Press, Dublin. Pp. 132-133.

20. Julius, V. A. 1907. Fauna, IN: A. Wright (Ed.), *Twentieth Century Imprisons of Ceylon*. Lloyd's Greater Britain Publishing Company Ltd. Pp 157-160.

21. Le Bruin (cited in Officer (an) Late of the Ceylon Rifles (1876) Ophidia - Snakes IN: *Ceylon a General Description of the Island, Historical, Physical, Statistical. Containing the Most Recent Information*. Vol. 2. Chapman & Hall, London.

22. Read MA, Grigg GC, Irwin SR, Shanahan D, Franklin CE. 2007. Satellite Tracking Reveals Long Distance Coastal Travel and Homing by Translocated Estuarine Crocodiles, *Crocodylus porosus*. PLoS ONE 2(9): e949. doi:10.1371/journal.pone.0000949

23. Ritchie, J & J. Jong. 2002. *Man-eating crocodiles of Borneo*. Nat. History Publications (Borneo), Kota Kinabalu. 118 pp.

24. Rohanadeera, M. 2007. A crocodile charm inscribed on a block of stone found in the Giñgañga at Badedegama, Circa 1469-1474. *Inscriptions of Ceylon*. Vol. 8: 58-70.

25. Saar, J. J. 1672. *Ost-Indianische Funfzchen-Jahrihe Kriegs Dienst.* Ceylon portion translated by P Freudenberg. *J of the Royal Asiatic Society (Ceylon Branch*), XI (39) published 1889.

26. Somaweera, R. & De Silva, A. 2013. Using traditional knowledge to minimize human-crocodile conflict in Sri Lanka. In Crocodiles. *Abstracts*: 22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group. P. 63.

27. Tennent, J. E. 1861. Crocodiles In: Sketches of the Natural History of Ceylon with Narratives and Anecdotes, Longman, Green, Longman and Roberts,London. pp.282-289.

28. Wallace, K. 2010. *Human Crocodile Conflict in the Chiawa Game Management Area, Zambia.* Update report for the IUCN-SSC Crocodile Specialist Group, Student Research Assistance Scheme, Imperial College London. 18 pages.

29. Wickramasinghe, D. P. 2001. *Maga digata Janakatha* 2. (= folk stories) Sooriya Publishers, Colombo. ISBN 955-8425-22-2. (Text in Sinhala).

Figure 1. People bathing/washing in a tank

Figure 2. Tank fishing.

Figure 3. Leg attacked by crocodile

Figure 4. Upper thigh attacked by crocodile

Figure 5. Arm attacked by crocodile

Figure 6. Arm attacked by crocodile

Figure 7. Buttocks attacked by crocodile

Figure 8. Trunk / chest attacked by crocodile

Photographs : Anslem de Silva

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN SSC Crocodile Specialist Group
pp 234 - 235

Discovery of a 2nd fossilized tooth of an extinct crocodile from Sri Lanka: Preliminary report

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Abstract

The first fossilized crocodile tooth from Sri Lanka was secured by P. E. P. Deraniyagala in July 1939 in gem sand in a gem pit at an approximate depth of 12 feet in Tunhiriya vila, Gönapitiya, Kuruvita, Sri Lanka. In March, 2013, a second undamaged fossilized crocodile tooth was discovered at a depth of 5 m from the same Pleistocene bed at Kuruvita village.

Introduction

Crocodilians had their evolutionary beginnings more than 250 million years ago in the early Triassic (Seymour *et al*., 2004). The oldest known fossil of a modern crocodilian is about 125 million years old (Brazaitis and Watanabe, 2011). The British Museum of Natural History (1922) reports of possessing several extinct crocodile species in their collection including a large collection from the Pliocene Siwalik formations of India that contained a snout of a colossal extinct gavial *Rhamphousuchus crassidens* which might have attained a length of about 16 m.

Deraniyagala reports that on 17th July 1939 a fossilized crocodile tooth fragment was secured from a gem pit in Tunhiriya Vila, Gonapitiya, Kuruvita (Deraniyagala, 1953, 1958). The tooth was discovered at a depth of 12 feet. Another gem pit in the vicinity yielded hippopotamus and rhinoceros fossils in the same degree of mineralisation as the crocodile tooth. In March 2013 the authors secured another fossilized crocodile tooth from the same Pleistocene bed, close to the location where Deraniyagala collected his fossilized crocodile tooth. The present communication is a preliminary discussion on these 2 fossil crocodilian teeth.

Materials and methods

The fossil tooth fragment collected by P. E. P. Deraniyagala in 1939 is held at the National Museum, Colombo, registered No. F. 28 (Figure 1). This second, undamaged fossilized crocodile tooth (Figures 2 and 3), was discovered at a depth of 5 m in March 2013 at Korawakwila, Edandewela, Kuruwita, Ratnapura. It is at the present time with one us (KA) and will be eventually deposited in the National Museum. Measurements of the fossil teeth were taken with veneer calipers Valley dial caliper, Valley Industries, USA.

Discussion

According to Deraniyagala (1958), the fossilized crocodile tooth fragment (Figure 1) had been along with the teeth of an extinct Rhinoceros, and within the same bed, in a close by gem pit had yielded fossil fragments of an extinct hippopotamus and rhinoceros. Deraniyagala (1953) considered that this fossilized crocodile tooth belonged to an extinct crocodilian. Furthermore, as this tooth was more slender with a more re-curved apex when compared with the teeth of the two extant species of the country, he considered that it 'might belong to a new species which might eventually be named *Crocodylus sinhaleyus'* (Deraniyagala, 1953, 1958). This tooth fragment (Figure 1) when we measured was 45.3 mm in height and 14 mm wide at the broadest place, this was slightly less than the measurements given by Deraniyagala, as according to the museum staff it has got slightly damaged. Deraniyagala (1953, 1958) estimated that this particular tooth had belonged to a crocodile measuring approximately 12 feet or more in length. He further reports that at the time of writing the only crocodile species known from Kaluganga close to Ratnapura, about seven miles southeast of Kuruvita is *Crocodylus porosus* (the Saltwater crocodile). *Crocodylus porosus* is still known from the river Kalu, but is uncommon.
Deraniyagala (1958) postulates that during the 3rd interglacial about 1,50,000 B. C. there had been large natural lakes around Ratnapura that supported large mammals and proposed the term *Ratnapura fauna* for these extinct fauna, as most of the Pleistocene fossils found in Sri Lanka were embedded in the gem gravels or alluvial deposits of the Ratnapura area. According to Deraniyagala (1958) and Manamendra-Arachchi and Adikari (2011), these fossils of extinct fauna resemble closely the extinct Indian *Shivalik fauna*. The extinct large mammals of Sri Lanka include two species of

rhinoceros (*Rhinoceros sinhaleyus* and *R. kagavena*), a hippopotamus (*Hexaprotodon* [=*Hippopotamus*] *sinhaleyus*) and a gaur (*Bos gaurus sinhaleyus*). Radiocarbon dates are not yet available for the two crocodile teeth fossils but thermo-luminescence dating is available for the extinct *Rhinoceros sinhaleyus* with a range of 80,000 (± 20,000) years before the present (S. Deraniyagala, 2004; Manamendra-Arachchi et al., 2005; Manamendra-Arachchi and Adikari, 2011). Here it is of interest to note that the first crocodile tooth fossil was found in the vicinity of the extinct rhinoceros fossils which "were of the same degree of mineralization" (Deraniyagala, 1953). Thus, it is possible that the particular crocodile tooth (Figure 1) is of the same age.

Some measurements of the second fossilized crocodilian tooth (Figures 2 and 3) are: the maximum height, 79.39 mm; maximum width (horizontal) of root, 23.55 mm; maximum height of root, 64.36 mm; maximum crown height, 24.48 mm; maximum crown width, 14.45 mm. The tooth is generally "S" shaped. It was collected by K.M. Premawardhana in a gem pit, approximately 5 m below the surface at Korawakwila, Edandewela, Kuruvita, Ratnapura in March 2013. This fossil was in the same Pleistocene bed at Kuruvita that Deraniyagala (1958) found his specimen. Ours, however, is complete and in a well preserved state (Figures 2 and 3) when compared to the sample collected by Deraniyagala which was a fragment and badly damaged (Figure 1). As regards the tooth collected by Deraniyagala, he states that if the tooth is reconstructed it would probably measure 95 mm in length (Deraniyagala, 1953, 1958).

Considering Deraniyagala's (1958) postulation that during the 3rd interglacial there had been large natural lakes around Ratnapura that supported large mammals, we could assume that this extinct crocodile would have been a lake species that lived alongside large aquatic and marshland mammals like hippopotamus, rhinoceros, water buffalo and gaur. Today there are no natural lakes in Sri Lanka, the main inland waters being the several thousand man-made reservoirs, known as 'tanks' the building of which commenced around the 6th century BC.

Detailed work on these fossil crocodile teeth as well as on geologic and climatic changes, events that took place like drying up of the large lakes and other possible causes for extinctions is underway, hence this preliminary account.

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Literature Cited

1. Brazaitis, Peter and Watanabe, Myrna E. 2011. 'Crocodilian behaviour: a window to dinosaur behaviour?'. *Historical Biology,* 23(1): 73-90.
2. British Museum of Natural History. 1922. *Guide to fossils reptiles, amphibians ad fishes.* British Museum of Natural History, London. 112 pp.
3. Deraniyagala, P. E. P. 1953. *A coloured atlas of some vertebrates from Ceylon.* Vol. 2. National Museums Publication. Ceylon Govt. Press. 101pp.
4. Deraniyagala, P. E. P. 1958. *The Pleistocene of Ceylon*. Ceylon National Museums Natural History Series. Govt. Press. Colombo, 164pp.
5. Deraniyagala, S. U. 2004. *Prehistoric basis or the rise of civilisation in Sri Lanka and southern India.* Sri Lanka Deputy High commissioner in Chennai. 28 pp.
6. Manamendra-Arachchi, K., R. Pethiyagoda, R. Dissanayake & M. Meegaskumbura. 2005. A second extinct big cat from the late Quaternary of Sri Lanka. In: Yeo, D. C. J., K. L. Ng & R. Pethiyagoda (eds.). *Contributions to biodiversity exploration and research in Sri Lanka. The Raffles Bulletin of Zoology*, Supplement No. **12**: 423-434 pp.
7. Manamendra-Arachchi, K. N. and G. Adikari. 2011. Extinct large mammals of Pleistocene period in Sri Lanka. *Abstract Volume, International Conference of the International Association for Asian Heritage* 2011. 7th and 8th April 2011, Colombo. Page 8.
8. Seymour R. S., Bennett-Stamper C., Johnston, S.D., Carrier, DR and Grigg, GC. 2004. Evidence for endothermic ancestors of crocodiles at the stem of archosaurian evolution. *Physiol Biochem Zool*. 77(6):10511067.

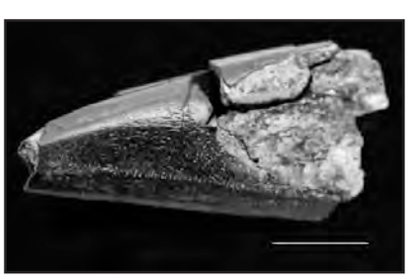

Figure 1. Fossil tooth fragment collected by Deraniyagala

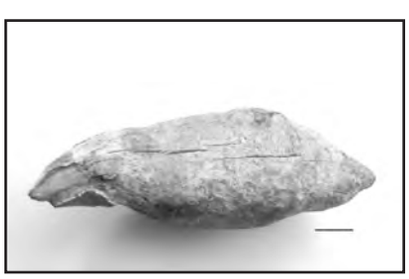

Figure 2. Second Fossil tooth

Figure 3. Second Fossil tooth

Photographs : Kelum Manamendra-Arachchi

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN SSC Crocodile Specialist Group
pp 236 - 237

Preliminary observations of some nesting strategies of *Crocodylus palustris* in Sri Lanka

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Abstract

Data on nest selection sites of the mugger crocodile *Crocodylus palustris* in Sri Lanka is predominantly based on anecdotal observations and date as far back as Parker's report in 1880. During the ongoing island-wide surveys of crocodiles we observed 41 mugger nests. These egg-laying sites indicate that the mugger uses three distinct strategies to lay eggs. Our observations complement the limited information available on the reproductive habits of the mugger in Sri Lanka. We observed a few nests alongside busy roads and human habitations.

Introduction

Whitaker and Whitaker (1984) provide a fairly comprehensive paper on the reproductive biology of the Indian Mugger. Reviewing the available literature from Sri Lanka that refers to or includes notes on the reproductive habits of the mugger, we see that the mugger selects a variety of places to lay its eggs. Parker (1880) is perhaps the first to report on the selection of sites used by the mugger to lay eggs, followed by Abercromby (1913); Deraniyagala (1930); Phillips (1941); Somanader (1941); de Silva (2013); de Silva et al., (2013) and Rathnasiri et al., (2013). Data from the present study give a fairly good picture of some mugger strategies in selecting a nesting site and other associated reproductive patterns. Our report of the mugger laying eggs alongside busy anthropogenic areas is perhaps the first report for the country.

Methods

The observations were investigated by the authors separately and opportunistically during the years 2003 to 2013 in many areas of the country. Additional data received from colleagues and some officers of the Department of Wildlife Conservation are also included.

Results, discussion and recommendations

According to our own data as well as from the available literature pertaining to Sri Lanka, the sites in which the mugger has selected to lay her eggs can be grouped under the following.

Table 1 Distribution of the sites selected by the 41 muggers to lay eggs

Site selected to dig the nest	No. observed	No. recorded in literature	Total
1. Sandy place on tank bund	16 (39%)	5 (Clark, 1901; Deraniyagala, 1939; Somanader, 1941; Phillips, 1941 and Gabrial et al., 2013)	21 (44 %)
2. As above but with a close by guard burrow	4 (10%)	1 (Parker, 1880)	5 (10%)
3. At the entrance of the burrow	17 (41%)	1 (Abercromby, 1913).	18 (38%)
4. Anthropogenic habitat	4 (10%)		4 (8%)

Selection of the site to excavate the nest

The above data suggest that the favourite or most widely selected (44%) nesting site by the mugger are item 1, sandy places in tank/river or stream banks without much scrub vegetation, with no decaying vegetation, with dappled sunlight, close to water and where few people or buffalo/cattle come. (Fig. 1, 2) This site is recorded by Parker (1880), Abercromby (1913), Deraniyagala (1930); Phillips (1941); Somanader (1941) and de Silva (2013).

As regards the next most widely selected (38%) place to dig the nest is (item 3) in front of the mugger burrow entrance, Abercromby (1913) was the first report this from the country. However, as regards item 2, the method where the nest is dug on a sandy bank with a nearby guard burrow, (Fig. 2) we have observed this strategy in two completely different scenarios: nest on a bank with a guard burrow inside forest, at a place not accessible to humans or buffalo/cattle, while the other was in fairly busy anthropogenic habitat in Tissamaharama (south east) and Kekirawa (north central province). (Fig. 3) Perhaps the possible reason in a forest could be protection from predators such as jackal, wild boar, wild cats and monitor lizards. However, crocodiles living in/around human habitats may be explained due to Human-crocodile co-existence observed in some areas in Sri Lanka, for example at Godadora Ela (irrigation canal) in Tissamaharama, where large muggers come to compounds to bask, nest and make burrows. One of the first to report this was Clark in 1901 that '…bathing unconcernedly in a tank with the heads of half-a-dozen of these brutes showing above the surface only a few yards from them'. Whitaker and Whitaker (1989) state: 'Today the traditionally amicable relationship between man and mugger can rarely be illustrated in India; muggers are too scarce. In Sri Lanka, however, there are many places where people bathe in "crocodile infested waters" without fear'. I can add that there are still some areas in Sri Lanka where people live virtually side by side with the mugger. Whitaker's (1989) comment that the 'mugger is a more "socially acceptable" species of crocodile" is interesting. However, we have not as yet observed using rock caves/crevices in far off secluded places as reported by Abercromby (1913).

A clearer idea of the reproductive cycle of the mugger and its general reproductive strategies will give us a better picture for devising both appropriate conservation measures and the necessary data to put in place robust protection for crocodiles and humans.

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Literature Cited

1. Abercromby, A. F. 1913. Some notes on the breeding habits of some Ceylon snakes and reptiles. *Spolia Zeylanica* 9(34): 143-147.

2. de Silva, Anslem. 2013. *The Crocodiles of Sri Lanka* (*Including Archaeology, History, Folklore, Traditional Medicine, Human-Crocodile Conflict and a Bibliography of the Literature on Crocodiles of Sri Lanka*). Author. AMP Print Shop, Gampola, 254 pp + 72 plates.

3. de Silva, Anslem, GWRP. Rathnasiri and A. R. Gabrial. 2013. Preliminary observations of the selection of nesting sites of *Crocodylus palustris* in Sri Lanka. *Book of Abstracts, World Crocodile Conference* (22nd Working Meeting of the IUCN-SSC, CSG). P 14.

4. Deraniyagala, P. E. P. 1930. Crocodile of Ceylon. *Spolia Zeylanica* 16(1): 89-95.

5. Deraniyagala, P. E. P. 1939. *The Tetrapod reptiles of Ceylon. Vol.1 Testudinates and crocodilians*. National Museum, + 412 pp .

6. Gabriel, Adrian R. 2013. The Status of the Mugger Crocodile (*Crocodylus palustris*) Inhabiting the Wilpattu National Park, Sri Lanka

7. Parker, W. K. 1880. *Crocodilus palustris. Proceedings Zoological Society, London*: 186-187

8. Phillips, W. W. A. 1941. A crocodile nest. *Loris* 2(5): 275-277.

9. Somanader, S. V. O. 1941. The swamp crocodile of Ceylon. *Loris* 2(4): 227-229

10. Whitaker, R. & Z. Whitaker. 1984. Reproductive biology of the mugger (*Crocodylus palustris*). *J. Bombay Nat. Hist. Soc.* 81(2): 297-317.

11. Whitaker, R. and Z. Whitaker. 1989. Ecology of the mugger crocodile IN: *Crocodiles their ecology, management, and conservation.* IUCN, Gland, Switzerland. pp 276-296.

Figure. 1

Figure. 2

Figure. 3

Photographs : Anslem de Silva

A Preliminary study on human crocodile relationship in Urubokka Oya, sothern province of Sri Lanka

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A preliminary study was conducted to assess the impact of humans on crocodiles and vice versa along the Urubokka Oya / Maha Oya (oya = river) in Humbantota District, Sothern Province of Sri Lanka. This river provides good habitats with both rocky and muddy river banks and muddy shallow water. The river mainly flows through paddy cultivated lands and villages. Approximately 250 person hours were spent in the field over a period of six months from October 2012 to March 2013 to assess the relationship between humans and crocodiles. General area surveys and questionnaire were used as tools of data collection. No crocodiles were captured during the study. In average ~3 individuals of Mugger Crocodile *(Crocodylus palustris)* were recorded in a given field day, with total body length (TBL) ranging from ~0.3m to ~3m. No written record was found of humans been killed by crocodiles of this river or vice versa. One verbal record was found about a crocodile which have killed two humans in 2001 and the animal was captured by the officials of Department of Wild Life Conservation. During the last twelve years 9 crocodile attacks were recorded with 2 deaths, 3 major injuries and 4 minor injuries. However 12 crocodile (TBL: ~0.3m to ~5m) deaths were recorded with 4 been killed by shooting, 5 been killed by beating and 3 juveniles found in an adjoining agricultural well killed by some chemical probably a pesticide. Altogether 8 crocodiles (TBL: ~0.6m to ~4.5m) have been captured and 3 have been handed over to Department of Wild Life Conservation. Out of the other five, 2 (TBL: ~1m) have been released to Kalametiya Bird Sanctuary and there are no record about what happen to the other 3 captured crocodiles. According to this survey it is prominent that there is a developing human crocodile conflict along Urubokka Oya and it will increase as the human population grows. Therefore there is a need of a much in-depth study in order to have better management plans.
Key Words: human crocodile conflict, Urubokka Oya, conservation, Sri Lanka

The status of the mugger crocodile (*Crocodylus palustris*) inhabiting the Wilpattu National Park, Sri Lanka

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Wilpattu National Park (WNP) is the largest national park in Sri Lanka and spans an area of 365,000 acres (148,000 hectares). Large saucer shaped water bodies known as Villus that fill up and consists almost entirely of rain water is a unique geographic occurrence at Wilpattu and is the basis of the name which translates to 'Lake District'. The present status and distribution of crocodiles within the park is not known as there were no detailed studies carried out in recent times especially in the last ten years when the civil conflict was at its peak. The park is now open since the conflict ended in May 2010. The preliminary survey to ascertain the status of crocodilians at WNP was conducted during August 2011. During which period 27 Villus were investigated during the day and at night 14 villus were surveyed using eye-shine technique. The counts were carried out from the bank in both instances. The day counts revealed 27 crocodiles the while night counts revealed 50. Six burrow sites were discovered and examined. The two river systems that border the park in the North and South, the Modaragam Aru and Kala Oya respectively were well watered. Both systems were not adequately surveyed. However a nest site in Kokmutai by the Modaragam Aru was discovered on 7th September 2011 with 13 egg-shells scattered, nine hatchlings and a guard burrow. The nest site was surveyed. Some of the hatchlings were captured and measured. It was the first recorded Mugger nest sighting reported from WNP. Due to the prevalent dry conditions of the time, most Villus had considerably shrunk in size and many had dried up completely. Despite the fact that no overland migrations to the two rivers were witnessed during the study it was thought to be the likely reason for the low counts from WNP. It is recommended that a further annual cyclical study be conducted to better ascertain the carrying population of crocodilians in the park and verify the possibility of the inter villu and villu to river migrations during the dry season.

Treatments and medical management of hook engulfed saltwater crocodile *(Crocodylus porosus)*

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Abstract

The saltwater crocodile *(Crocodylus porosus*) also known as the estuarine or Indo-Pacific crocodile, and the largest of all living reptiles. As well as the largest terrestrial and riparian predator in the world. Due to anthropogenic activities and involvements to natural habitats numbers of these crocodiles are declining. According to the observations during t6he last 3 years a trend was build up by the affected people of the area to use hook to trap crocodiles. As such they use iron hooks anchor trap hooks with a dead bait of a dog or a cat or some ox meat. At the engulfing process this iron anchor or hooks penetrate to laryngeal area of throat or esophagus. If animal trap it cable connected with that hook hunters pull the animal and may be kill or allow to animal for die with several days. This inhumane process people use clearly for killing the animal not for capture. Some crocodiles die immediately after engulf due to damage indirectly to aorta. Other animals stay several days and ultimately they were dying due to starvation and other sevior traumatic injuries and complications. Traumatic injuries and other complications were aggravated due to struggling immediate after engulfing of hook. These incidents were increasingly reported during the few years; the areas where crocodiles and human deaths were occurred. In this paper two cases were taken in to consideration which a hook engulfed crocodiles and some observations in the process of medical management.

First case the crocodile was 10feet long average body weight 600kgs was recorded find out with hook engulfed from area at Beruwala. Animal was depressed, externally several wounds over body surface. Cable connected with hook was already visible externally. The first step was to sedate the crocodile by using Ketamin Hydrochloride. However after examine the animal it was find condition of animal is not suitable for sedation. Later it was decided to remove the hook by manual restraining. Wooden plate with central hole and iron bar square apparatus use as a mouth gag. This was facilitated specialy for this purpose. Stretch the mandible and upper jaw by use ropes and fix the wooden plate in between two jaws. Insert hand through the mouth gag to throats and inspected the severity of the damage. It was a anchor hook with two sharp edges at two directions. Both two edges were deeply penetrated to ventral and part of the proximal edge of the esophagus. It was very hard attempt and very difficult process to remove the hook, reason was if remove one hook simultaneously other edge of hook entangle. The design of hook very hard to remove both edges at the same time and if try to remove simultaneously increase the damage of surround tissues. About 20 minutes tried to remove the hook which failed. Meanwhile crocodile was died. After the death the surgical procedures followed to reach to place by ventrally thoracic opening. Incised the skin and muscle layers of thoracic area ventrally parallel to hook engulfed area. Opened the xipoid cartilage and access to place. It was evident a seviorly traumatized tissues around there and already necrosed.Sevior bleeding lesions also observed. Due to primary struggling of hook engulfing all the tissues around the area was damaged and with the time it was necrosis.

Second case was saltwater crocodile captured by people in Ragama area which was suspected of victim for one human death. It was trap with a designer hook which consists with bunch of hooks complicity 3 hooks fixed in to three different directions. The animal was captured by Department of Wild Life Conservation and brought to the zoo. At the time of arrival it was a depressed and 4 inch long deep wound was found on the head which was suspected that that cause by an axe. Given Dexamethasone 20ml, Cyanocobalamin 25ml, long acting Penicillin 30ml, Hydrocortisone succinate, deep intramuscular.Localy dressed the head wound. Same procedures perform as earlier case and try to remove hook by manually. But after heavy manipulation within 30 minutes remove the hook. During the process the crocodile died. The caercas was open it in necropsy revealed sevior damageoccured due to engulfing of hook. Suspected human hand and foot bones already find out from stomach content of crocodile. Those were sent for further forensic investigation.

According to these two cases it was observed manual manipulation and attempt to remove hooks were not successful and it could damage the surrounding tissues furthermore. Surgical attempts are non practicable with post operative care. Always hooked engulfed crocodiles were very week and dipressed.Their prognosis was very poor due to extensive damage to throat. According to this cases the recommendation is first inspect the engulfed hook and level of penetration by manually. If minor attachment to tissues can remove the whole hook manually. If it is a strong attachment do not try to remove whole hook manually. However to save the life of the animal it may be possible to cut the cable connected to the hook from its deepest end inside the crocodiles body.Reamaining iron hook inside the throat or esophagus wall can be settled in it as it is. For control of the infection of surround tissues can give Long acting Penicillin and as anti inflammatory Flunexin maglumate intramuscularly

Preliminary observations of *Balantidium* infections in marsh crocodile in Jaffna Peninsula

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The mugger or marsh crocodile *(Crocodylus palustris)* has been recorded from many locations in the country with a majority from Yala and Wilpattu National Parks in large rivers, marshes, reservoirs and tanks in the low country dry zone and also from Jaffna Peninsula. Parasites of crocodiles in Sri Lanka have not been studied previously. Faecal samples were collected from muggers in Jaffna peninsula in November 2012. Each sample was divided into two and few drops of formalin was added to one portion and the other was kept either in a cooler at 4^0C or at room temperature (27-33^0C) until analysis. Samples were brought to the lab and processed by modified salt floatation followed by morphological identification using the light microscope. A total of 21 faecal samples were analysed from two locations in Jaffna namely, Ampan and Sarasalai. All the samples were positive for *Balantidium* cysts. The intensity of infection varied among the individuals with extremely high cyst counts from some individuals. DNA studies are underway to identify the *Balantidium* species. Although the presence of cysts of *Balantidium* has been recorded from faecal samples of crocodiles and alligators in commercial closed farming systems in other countries, this study provides first record of *Balantidium* infections in *Crocodylus palustris* of Sri Lanka.

Current conservation status of *Crocodylus porosus* from Borupana Ela and its hinterlands in Moratuwa, Sri Lanka

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Crocodylus porosus (CP) is the largest reptile species distributed in the coastal belt and its environs of Sri Lanka. This species is categorized as Lower Risk/Least Concern (version 2.3) under the IUCN Global Red List, and Endangered (B2ab iii) in the 2012 National Red List of Sri Lanka. Despite it being locally common in some regions in the island, data on general behavior, feeding and reproductive habits and also the genetic and morphological variation within the species in Sri Lanka is not well known. The data in this abstract are based on opportunistic field observations made by the authors for 37 days (~6 hrs/ day) from February 2012 to March 2013 in Borupana (Kospelana Bridge to Borupana Bridge). This study area covers less than 1000 hectares and falls within the western province (647'39.72" to 650'17.26" N and 7953'09.00"to 7954'48.31"E), at an elevation of 1-2 m above sea level. Surveys were conducted both during day and night and flashlights were used at night. Specimens accidentally caught in fishing nets were also examined. Whenever possible specimens were taken from fishermen to determine their sex, weight and obtain measurements and released at the same habitat. We also interviewed villagers using a written questionnaire. Furthermore basic environmental parameters were collected at locations, where specimens were collected.

During the survey we were able to record a total of 41 individuals (29 through fisheries by-catches and 12 direct observations). Out of the 29 specimens, eight were killed by fishermen for consumption. These individuals ranged from 14-180 cm (SVL) and weighed 0.08-53 kg. According to questionnaire surveys administered on villagers between 21 to 60 years in age (*n*=84), 96% of them believed that CP have no importance and should be killed; 89% has killed at least one CP in Borupana; 74% has eaten CP meat and 45% has eaten CP eggs. Contrastingly, among villagers below 20 years in age (*n*=53), 81% believed CP to be of importance thus should not kill; 86% not killed even a single CP in Borupana; 82% not eaten CP meat and 88% not eaten CP eggs as additional food source.

Borupana is a local 'Hot Spot' for CP and there is a healthy population in different size classes and good habitat for nesting. But few threats were noted: Karadiyana massive garbage dumping area is close to this site (potentially emitting toxic chemicals to the water), and several industrial factories dump their waste to Borupana Ela (7.2 to 7.9 ph level). Water temperature at ~30cm depth fluctuates between 29.3 to 30.8 C at night time and between 30.1 to 31.6 C during day time. Three fatal attacks from CP have been recorded from the area over the last ten years and eight other attacks have taken place. Five large individuals were removed from this location and translocation to Bundala, Yala and Lunugamwehera areas, which are inhabited by muggers. Education and awareness workshops for the villagers were also conducted over the last year.

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN SSC Crocodile Specialist Group
pp 243 - 245

Discovery of a 4th century AD perforated crocodile tooth ornaments from Sri Lanka

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Abstract

The first discovery of perforated crocodile tooth ornaments among 41 drilled tooth artifacts belonging to eight vertebrate species uncovered during standard archeological excavation procedures conducted at the Jethawanarama monastic site, Anuradhapura are discussed. These perforated tooth ornaments could possibly have been used as a necklace, arguably worn by a hunter. It is possible that the particular hunter who had killed these animals would have made a vow and placed these hunting trophies on the offering altar to lord Buddha averring that he will not commit such actions in the future.

Introduction

The wearing of various parts of animals such as bird feathers, mammal and reptile bones, shells, coral, horn, ivory and animal teeth as ornaments by man is known over several thousand years BP from many parts of the world (Vanhaeren *et al*., 2006). Royalty, chieftains and commoners would all have worn these during religious, sorcery, folk, fertility and agricultural rituals, during hunting (possibly as a protection or to get more game) and other activities. From Sri Lanka drilled shells of marine and freshwater molluscs and shark teeth have been discovered from different parts of the island, which are dated from 3,800 to 38,000 YBP (Deraniyagala, 1992; Perera, 2010; Manamendra-Arachchi and Adikari, 2012). However, there is no previous evidence of drilled crocodile teeth from the country. Thus we report for the first time the discovery of the drilled teeth of probably a marsh crocodile (*Crocodylus palustris*), along with the drilled teeth of at least 8 other vertebrate species uncovered during the Jethawanarama monastic site excavations.(Fig. 1) The present communication is mainly concerned with the crocodile teeth (Figures 2, 3, 4,5)

Material and methods

Forty-one drilled teeth artifacts belonging to at least 8 vertebrate species (there were 7 unidentified teeth fragments) were discovered during standard archeological excavation procedures conducted in 1984 at the Jethawanarama monastic site (Table 1 and 2). These were found buried in front of the offering table of the Northern Wahalkada or Ayakeya which is situated between the stupa and the entrance (Figure 1).

Table 1
The 41 Drilled Teeth artifacts

Vertebrate Species	No of drilled teeth
Crocodylus palustris (Mugger crocodile)	2 (and fragments of another 8)
Herpestes spp. (Mongoose)	6
Canis familiaris (Dog)	10
Prionailurus viverrinus (Fishing cat)	2
Melursus urisinus (Sloth bear)	1
Panthera pardus (Leopard)	3
Dolphin sp.	1
Hystrix indica (Porcupine)	1
Unidentified perforated teeth	7
Total	41

Table 2

Morphometric details of a perforated crocodile tooth

	Tooth sample 1	Tooth sample 2
Registered no	I.314 / A / NAY, Northern Ayakeya, 1984.9.24	I.314 / A / NAY, Northern Ayakeya, 1984.9.24
Total height	31.35 mm	27.17 mm
Base width	10.03 mm	8.76 mm
Base thickness	8.75 mm	6.91 mm
Outer diameter of the drilled hole	3.10 mm	2.91 mm
Inner diameter of the drilled hole	2.91 mm	2.62 mm

Discussion

Perhaps the oldest evidence of drilled vertebrate teeth ornaments we have to date is from Europe and goes back to the Paleolithic era. These ornaments were discovered during excavations at Come Sauniero, France (Castel *et al*., 2002). However, perforated marine mollusc shells are much older (1, 35, 000 to 1, 00, 000 YBP) and have been discovered from Israel and Algeria (Vanhaeren *et al*., 2006). Archaeologists consider these to be some of the oldest known drilled ornaments to be worn by humans. In Sri Lanka the perforated shells of aquatic (marine and freshwater) molluscs worn by prehistoric (Mesolithic) man between 3,800 and 38,000 YBP have been discovered from Fa-Hien cave at Bulathsinhala, Batadombalena cave at Kuruvita and Pothgul lena at Alawala, (Deraniyagala, 1992; Perera, 2010; Manamendra-Arachchi and Adikari, 2012). The oldest of these drilled shells from approximately 38,000 YBP, discovered from Batadombalena (cave), Kuruvita had been worn by the prehistoric man known as Balangoda man (Deraniyagala, 1992; Perera, 2010).

Though the use of perforated teeth ornaments had commenced during the Neolithic Period in European countries (Castel *et al*., 2002), no such artifacts have as yet been discovered from Sri Lanka. However, the discovery of 41 perforated teeth belonging to at least eight vertebrate species from the 4th century AC in Sri Lanka is important in several ways:

1. This is the first discovery of perforated terrestrial vertebrate teeth, especially that of the crocodile.
2. These would have been possibly used as a necklace or kept as hunter trophies.
3. Given the precise location of the find it is credible to believe that the particular hunter who had killed the animals had made a vow and placed these hunting trophies on the offering alter averring that he will not commit such actions in the future.

Of the 8 vertebrate species represented in this series, the crocodile probably accounts for the most damage to humans and their farm animals. As both of the crocodile species (*Crocodylus palustris* and *C. porosus*) of the country are known to attack and occasionally kill humans (de Silva, 2010, 2011) several precautionary measures were taken by vulnerable people to protect themselves (de Silva, 2011). In many instances the offending crocodiles were killed and a good and convenient memento would have been a crocodile tooth. In the past animal ornaments were usually worn mainly by village elders, hunters or a person who held some government position as an object of prestige or as hunting trophies or as a protective talisman.

It is still the common practice of many hunters to keep a memento of the animals they kill (shoot). It is note worthy that even today many pay hundreds of rupees for one hire of elephants tail, the elephant should be a wild one, that means no human have got on to its back. Usually these are worn as ring and are considered a good luck charm and a protection. Similarly, parts of the wild boar are considered a protection against witchcraft. We still see modern men wearing wild boar tassels, leopard or bear claws mounted in metal pendants (Figure 5).

It is highly possible that these perforated animal teeth found at Jethawanarama would have belonged to a hunter and were used as a protective talisman, a sign of a professional hunter, for prestige, to get more game or worn during some folk ritual.

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Literature cited

1. Castel, J., D. Liolios, V. Laroulandie, F. Chauviere, J. Chadelle, A. Pike-Tay & J. Geneste, 2002. *Solutrean animal resource exploitation at Combe Sauniere* (Dordogne, France). 9th ICAZ conference, Durham 2002, Integrating zooarchaeology (ed. M. Maltby), 138-152 pp.
2. de Silva, Anslem. 2010. *Crocodiles of Sri Lanka: preliminary assessment of their status and the human crocodile conflict situation*. (Report submitted after fulfillment of the project to Mohamed Bin Zeyed Species Conservation Fund) Author, Gampola. 49 p.
3. de Silva, Anslem. 2011. Prevention of crocodile attacks in Sri Lanka: some traditional methods. *Crocodile Specialist Group Newsletter*. 30(1): 28-31
4. Deraniyagala, S.U. 1992. *The Prehistory of Sri Lanka*: an ecological perspective. Memoir 8, 2nd ed. Archaeological Department, Colombo, 831 pp.
5. Manamendra-Arachchi, K. & G. Adikari. 2012. Unique Prehistoric creations from animal remains in Sri Lanka. *Palaeobiodiversity Congress, 2012*. Biodiversity Secretariat, Ministry of Environment, Sri Lanka, 298-323 pp.
7 . 6. Perera, H.N. 2010. *Prehistoric Sri Lanka, late Pleistocene rockshelters and an open-air site*. BAR International Series, 2142, xvi+268 pp.
Vanhaeren, M., F. d'Errico, C. Strinder, S.L. James, J.A. Todd & H.K. Mienis. 2006. Middle Paleolithic shell beads in Israel and Algeria. *Science*, Vol. 312: 1785-1788 pp.

Figure. 1

Figure. 2

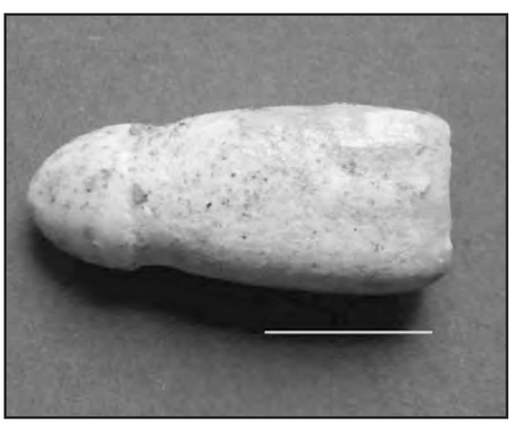

Figure. 3

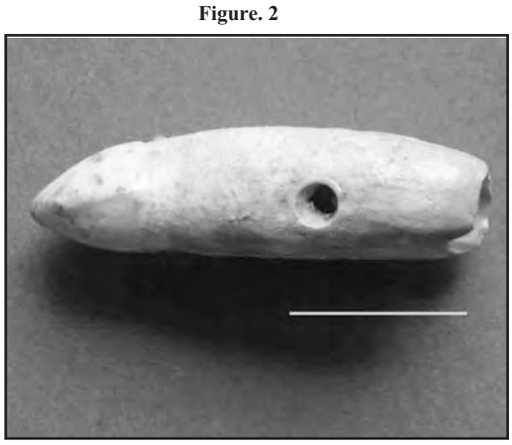

Figure. 4

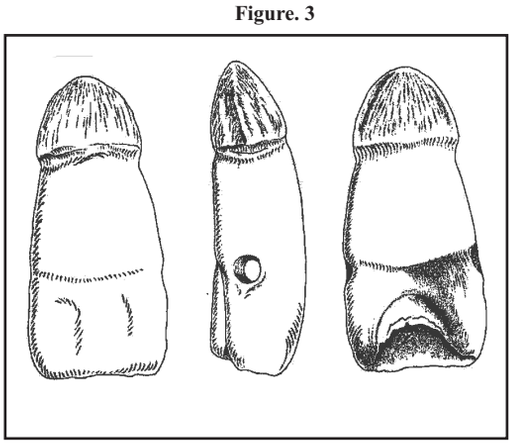

Figure. 5

Photographs : Kelum Manamendra-Arachchci

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN SSC Crocodile Specialist Group
pp 246 - 250

Mugger burrows: preliminary investigations into the unique tunnels excavated by *Crocodylus palustris* in Sri Lanka

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Abstract

Approximately 200 *Crocodylus palustris* (Mugger crocodile) burrows were observed at 26 different localities in Sri Lanka between 2002 and 2013. As some burrows were inaccessible due to high water levels, preliminary investigations were conducted of 103 of these. Two main types of burrows observed during field work were: the 'shelter' burrow, the burrow with egg nest near the mouth and the 'guard' or 'defense' burrow. The former is used during the hot dry season when its aquatic habitat is drying or dried, and the mugger virtually aestivates in the low temperature inside the chamber of the burrow. The 'defense' or the 'guard' burrow is used to stay closer to the nest and protect it from potential predators. The guard burrow is usually first made by the female after selecting an appropriate site. The average height and width at the entrance of the mugger burrow, the depth or the length of the burrow and the temperature inside the burrow were recorded. Of the 103 burrows, 42 were deemed 'active' with either muggers present inside or with signs of recent use. Some anecdotal reports of mugger burrows in Sri Lanka spanning the years 1880 to 2013 are highlighted.

Introduction

A burrow is defined as a 'hole in the ground dug by certain animals for shelter or defense'. Many of the crocodilians of the world dig burrows or tunnels (Bihui, 1990; de Silva, 2010; Rathnasiri, 2011; Rathnasiri et al., 2013; Steubing and Lim, 2004; Vijaykumar, 2000; Whitaker et al., 2007). Among crocodilians, *Crocodylus palustris* is well known for its burrows or tunnels (hereafter referred to as the Mugger Burrow = MB). They are used by muggers under various circumstances, such as a refuge for resting, thermoregulation, aestivation during prolonged drought and protection from natural predators and humans. Some are dug for guarding the nest (Parker, 1880; de Silva et al., 2013) and in these the nest is situated near the mouth of the burrow (de Silva et al., 2013; Rathnasiri 2011; Vijaykumar, 2000).

Crocodilian species found in the tropics use the burrow to survive the effects of drought and extreme heat. However, the Chinese Alligator (*Alligator Sinensis*) and the American alligator (*A. mississippiensis*) that range above 30º N where temperatures fall below freezing use the burrows as refuges from cold winter temperatures (Whitaker et al., 2007). For Sri Lanka, Deraniyagala (1939) reports that with the onset of a drought period, muggers feast on frogs and shoals of fish exposed by diminishing water. In this manner, they accumulate a fat reserve preparatory to aestivation either in burrows or under rocks deep in jungles.

Sri Lanka and Gujarat, India are two of the best places to observe MB's. In Sri Lanka they are popularly know as *kimbul gé* (*kimbul* = crocodile, *gé* = house) by the villagers. Approximately 200 mugger borrows were observed in various parts of the island, of which investigations were conducted in 103 burrows or tunnels (de Silva, 2010; Rathnasiri 2011; Rathnasiri et al., 2013). The other burrows could not be investigated as when we visited the water level was high and the burrows were submerged or there was difficulty in approaching the burrow.

In Sri Lanka we observed two main types of MB's during our field work: the 'shelter' burrow, and the 'guard' or 'defense' burrow the burrow. The former is used during hot dry season when its aquatic habitat is drying or dried, and the mugger virtually aestivates in the low temperature inside the chamber of the burrow. The latter type: 'guard' or the 'defense' burrows, we observed 2 varieties guard/ defense burrows. The typical guard burrow is usually first made by the female after selecting an appropriate site (see de Silva et al., 2013 in this publication) after which the female digs a pit to lay eggs few meters away and above the guard burrow. The other is she digs a 2 to 2.5 m burrow and dig a pit to lay the eggs at the mouth or slightly inside the burrow, thus the mother stay closer to the nest and protect it from potential predators. Thus, we see that in Sri Lanka the mugger use two versions of guard burrows. We observed in a few burrows that muggers, including hatchlings, can sometimes group together in a single tunnel, (de Silva, 2010; Rathnasiri 2011; Rathnasiri et al., 2013). Mugger's grouping together in a single tunnel is also recorded from India (Vijaykumar, 2000). Some details of the mugger burrows that were investigated are given below and in Table. 1.
The following are the available anecdotal reports of MB's from Sri Lanka spanning between 1880 and 2013:

1. W. K. Parker (1880) is the first to document from notes provided to him by one S. Waitialingam of a 'guard burrow'. He reports that the mother first makes a large hole for herself to live in during the day in order to watch her eggs.
2. A. F. Abercromby (1913) reports of crocodiles laying eggs in a deep hole in a bank.
3. K. W. S. Mitchell (1925) reports of an interesting account of digging out a crocodile from a 30 ft. long burrow on land.
4. P. E. P. Deraniyagala (1936) reports of the U-shaped mugger burrow found in riverbanks.
5. Whitaker and Whitaker (1984) referred to mugger burrows in Sri Lanka.
6. Brady Barr (2002) mentions initiating investigations in *C. palustris* of selection of burrow sites, mapping of burrows and their biological significance, and the thermoregulatory role burrows play in the biology of the mugger crocodile.
7. R. Whitaker et al., (2007) reports more details on MB in the Bundala National Park, Sri Lanka.
8. Anslem de Silva (2010) reports some details of 26 MB mainly from the North Central province.
9. G. W. R. P. Rathnasiri (2011) reports details of 18 MB from the Udawalwe National Park.
10. Rathnasiri et al. (2013) reports briefly of 105 MB from several locations in the country.
11. Adrian R. Gabriel (2013) reports on six MB from the Wilpattu National Park.

However, this study is the first detailed paper on the MB of Sri Lanka.

Methods and material

From the year 2002 up to 2013 approximately 200 MB's belonging to the three types were observed at 26 different localities in the country (north from Jaffna to south Bundala, Yala). As some burrows were inaccessible due to high water levels, we were able to conduct preliminary investigations in only 103 of them. MB's were investigated at different times during the day by the survey team. A measuring tap was used to take measurements of the height and width of the entrance of the MB. The depth of the burrow was taken by fixing several 1 m long plastic tubes with sockets, a 15 m nylon cord was passed through the tube and fixed to the first pole (Figure 1) so that pole could be pulled back. A digital thermometer was fixed to the first tube to take the inside temperature (Figure 2). Once the plastic rod hit the end of the tunnel, it was kept there for 5 to 6 minutes after which it is was pulled back rapidly (Figure 3) and the temperature immediately noted. The ambient temperature as well as the temperature at the entrance of the MB was taken. Compass orientation of the entrance and the GPS location was recorded. Digital images of the burrow entrance and sometimes inside, as well as how far it was from water, soil type, vegetation around and above the burrow and threats to the burrow were taken. All data were recorded in a structured survey form,

Results, conclusions and recommendations

According to Whitaker and Whitaker stream-dwelling mugger's use tunnels as year round residences, preferring embankments with heavy root systems (Whitaker and Whitaker, 1989). In Sri Lanka we observed similar MB in Yan Oya (stream), tanks and with heavy root systems, also some with small roots (Figures 4) The mugger uses its snout and the forelimbs to dig the burrow. Once it has dug up to its body length, the hind limbs and the tail are used to push the soil back out from the tunnel. One of us (PR) observed a mugger breaking roots jutting into the tunnel. However, the time taken to dig the entire tunnel is not known, however, it is possible that a crocodile could dig a burrow within a few days. Whitaker and Whitaker (1984) referred to mugger burrows in Sri Lanka and India (Gujarat and South India) and noted that yearling, sub-adult and adult mugger all dig burrows. At Yan Oya we observed 35 MB in a row about 3 to 10 m apart (de Silva, 2010 ; Rathnasiri , 2011), Mobaraki (2002) reports observing two burrows close to each other in Iran.

The average height and width at the entrance of the mugger burrow were 43.16 cm (range 20-90 cm) and 80 cm (range 29-154 cm), respectively. The depth or the length of the burrow varied from 100-1100 cm with an average of 310 cm. Most of the deepest MBs (ranging from 800-1100 cm) were observed at Yan Oya (N 7° 25′ 32.5′′ and E 80° 27′ 31.4′′). The temperature inside the burrow was usually about 3 to 10 ºC less than the outside temperature. A chamber where the crocodile rests was present in 94 (90%) burrows. Of the 103 burrows, 42 (40%) were deemed 'active' with the presence of a mugger (Figures 5, 6).

Burrows at three different heights above water level; 5-10 m up the bank, at the water level and at the middle of the bank between water level and the top have been observed in the Gir Forest, India (Vijaykumar, 2000). In Sri Lanka we have observed at the bottom of the bank and around mid bank. This may be as all banks that we investigated during the study was less than 5 m tall. Gupta and Srihari (1990) who studied mugger burrows at Bhorsaindan Sanctuary, India reports that burrow utilization was greater in winter months when temperatures dropped to 11º C. Shekar (1993) reported two to six muggers in the same burrow in winter months at this Sanctuary. However, in Sri Lanka in the dry zone plains where the muggers inhabit the temperature does not go below 24º C, and there are no winter or summer seasons, thus use of the burrows as refuges from cold does not arise.

The height and width of the burrow entrance (Figure. 3) and the depth and temperatures at burrow surface and inside the burrow of an earlier study in the North Central Province (de Silva, 2010) are given in Table 1.

Table 1. Some measurements of mugger burrows

	Number	Minimum	Maximum	Mean	Std. Deviation
Burrow height (cm)	21	30	75	49.52	11.237
Burrow width (cm)	22	54	142	83.91	22.209
Burrow depth (m)	20	2	12	5.82	2.939
Ambient temperature (oC)	16	24	38	29.89	4.703
Surface temperature (oC)	18	23	33	26.92	2.871
Inside temperature (oC)	18	19	30	24.28	2.600

(Source: A. de Silva, 2010)

The number of MB in a particular area does not equate to the number of muggers present in that particular locality. Romulus Whitaker (personal communications to AdS, 2011) who has worked in India, Sri Lanka and many other countries stated that in one place in Gujarat where he counted 19 burrows there were over 100 muggers. Similarly, Vijaykumar (2000) reports that he observed only 58 burrows at Hiran dam where around 200 muggers exist and he assumes that muggers will group together in a single tunnel. This indicates that only some dig tunnels. Furthermore, Whitaker (in lit.) informed that 'there is mixed information as to how many crocodiles will go into one burrow. A big male will probably occupy a burrow and not allow others in. Smaller muggers may stay in a big burrow previously made by a bigger mugger. There are variables of all kinds that no one has yet quantified'. During our survey we once observed an adult (possibly the mother) with 15 hatchlings (counts made by eye-shine technique) in one burrow (Figure 5 & 6).

Threats to Mugger Burrows

Illegal sand mining was seen taking place close to burrows (Figure 7). We also observed the barricading of the entrance of MB with poles and the fixing of a noose when the mugger was inside (Figure 8.) (de Silva, 2010). Additionally, we saw that during the renovation of tank bunds MB were being destroyed.

Conservation and eco-tourism

Sri Lanka is at the present time known as the world's hotspot for the mugger crocodile. Several international film companies (National Geographic, USA, BBC, Discovery, Animal Planet, etc) have produced and released TV documentaries about the mugger on channels the world over. Thus, some people would like to see the famous mugger burrows, and they could be used in eco-tourism (de Silva and Lenin, 2010). We feel that many would like to see the multi-purpose unique burrows made by an ancient group of reptiles of the world.

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Literature cited

1. Abercromby, A. F. 1913. Some notes on the breeding habits of some Ceylon snakes and reptiles. *Spolia Zeylanica* 9(34): 143-147.

2. Barr, B. 2002. Crocodile training program and research on the biological significance of *Crocodylus palustris* burrows in southern, Sri Lanka. *Crocodile Specialist Group Newsletter, 2*1(3):11-12

3. Bihui, C. 1990. Observation on the burrow of Chinese Alligator. IN: *Crocodiles, Proceedings of the 10th Working Meeting of the CSG, .IUCN*, 23-27, April, 1990, Gainsville, Florida: PP 47-53

4. de Silva, Anslem. 2010. *Crocodiles of Sri Lanka: Preliminary Assessment of their Status and the Human Crocodile Conflict Situation*. (Report submitted after fulfillment of the project to Mohamed Bin Zeyed Species Conservation Fund), AMP Print Shop, Gampola. 49 .

5. de Silva, Anslem.. and Lenin, J. (2010). Mugger Crocodile *Crocodylus palustris*. Pp. 94-98 in *Crocodiles. Status Survey and Conservation Action Plan*. Third Edition, ed. by S.C. Manolis and C. Stevenson. Crocodile Specialist Group: Darwin).

6. de Silva, Anslem, GWRP. Rathnasiri and A. R. Gabrial. 2013. Preliminary observations of the selection of nesting sites of *Crocodylus palustris* in Sri Lanka. *Book of Abstracts, World Crocodile Conference* (22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group). P 14.

7. Deraniyagala, P.E.P. 1936. A new crocodile from Ceylon. The Ceylon**.** *Spolia Zeylanica***,** 19(3): 279-286.

8. Gabriel, Adrian R. 2013. The Status of the Mugger Crocodile (*Crocodylus palustris*) Inhabiting the Wilpattu National Park, Sri Lanka. *Book of Abstracts, World Crocodile Conference* (22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group). P 16.

9. Gupta, R.C. & P. Srihari. 1990. On the burrow utilization by the Indian marsh crocodile (Crocodylus palustris) at Borsaindan Crocodile Sanctuary, Haryana. *J. Environ. Biol.* 11(2): 169-178.

10. Mitchell, K. W. S. 1925. Digging out a Crocodile. *Times of Ceylon Sunday Illustrated*. 4(9): 516-519.

11. Mobaraki A. 2002. Snub-nosed crocodile (*Crocodylus palustris*) study in Iran. Pp. 253-256 *in Crocodiles.*Proceedings of the 16th Working Meeting of the IUCNSSC Crocodile Specialist Group. IUCN: Gland.

12. Parker, W. K. 1880. Crocodilus palustris *Proceedings Zoological Society, London*: 186-187 (brief account of reproductive habits, egg laying and hatching)

13. Rathnasiri, G. W. R. P. 2011. *Crocodile burrows at Udawalawe National Park*. Report submitted to Open University, (unpublished paper text in Sinhala).

14. Rathnasiri, G. W. R. P., Anslem de Silva and Adrian Gabrial. 2013. Mugger burrows: Preliminary investigations into the unique tunnels excavated by *Crocodylus palustris* in Sri Lanka. *Book of Abstracts, World Crocodile Conference* (22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group). P 51

15. Shekar, C. 1993. Ecological studies on Indian mugger (*Crocodylus palustris*) at Bhorsaindan Crocodile Sanctuary. Unpubl. Ph.D. Thesis, Kurukshetra University, India.

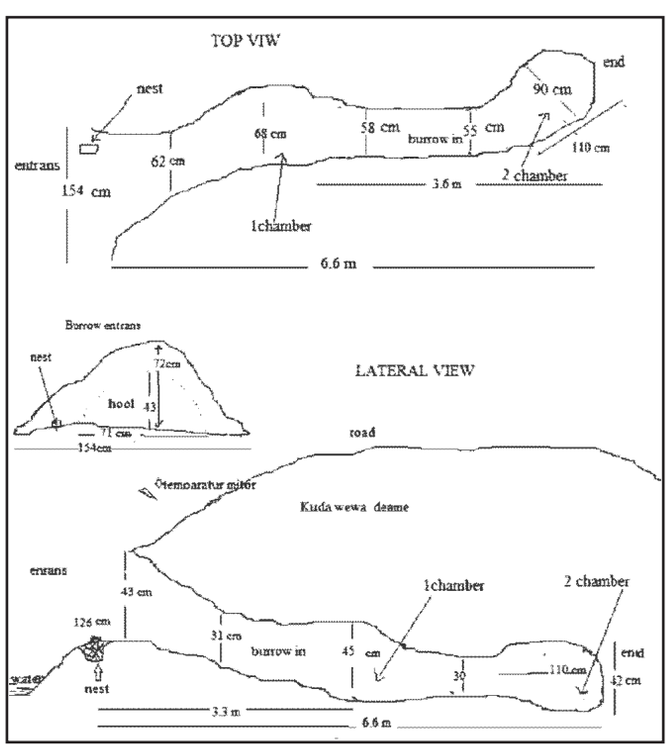
16. Steubing, R. B. and C.K. Lim.2004. Use of caves by *Tomistoma schlegelii* in Sarawak, Malaysia. CSG news bulletin, 23(4): pp. 11-12

17. Vijaykumar, V. 2000. Mugger burrows: An adaptation to a harsh environment. *Crocodile Specialist Group Newsletter,* 19 (4): 16-17

18. Whitaker, R. and Whitaker, Z. 1984. Reproductive biology of Mugger. *J. Bombay Nat. Hist. Soc*. 81(2): 119-127.

19. Whitaker, R. and Z. Whitaker. 1989. Ecology of the mugger crocodile IN: *Crocodiles their ecology, management, and conservation.* International Union for Conservation of Nature and Natural Resources, Gland, Switzerland. ISBN 2-88032-987-6. pp 276-296.

20. Whitaker, R., Brady Barr, Anslem de Silva and P. Rathnasiri. 2007. Observations on burrows dug by mugger crocodiles (*Crocodylus palustris*) in Bundala National Park, Sri Lanka. *Bombay Nat. Hist. Soc*., 104 (2): 19-24.



Meassurments of a 6.6 m long burrow

Figure. 1

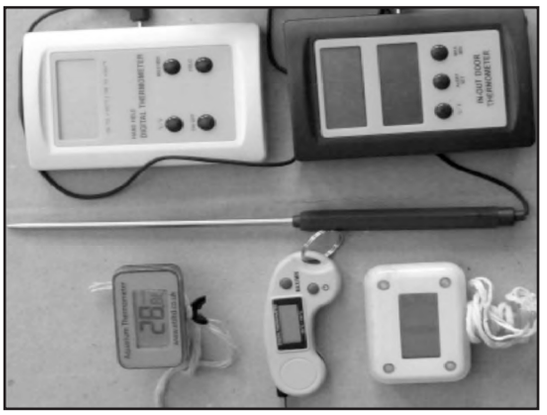


Figure. 2

Figure. 3

Figure. 4

Figure. 5

Figure. 6

Figure. 7

Figure. 8

Photographs : Anslem de Silva and Pradeep Rathnasiri

Human- crocodile conflict in Nilwala River: a social science perspective

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Interactions between humans and crocodiles in the Nilwala River were present for centuries. However, during the past decade a total of 15 fatalities were recorded and eight crocodiles were killed in response to the four human attacks, as food and for protection last year. Therefore this interaction has gradually progressed in to a conflict. The main objective of the study was: Understand the root cause of the humancrocodile conflict and find out the barriers to overcome the problem and propose recommendations to conserve crocodiles and enhance human well being in Matara. A structured questionnaire of 32 questions was developed to assess the knowledge, attitude and practices of people, additionally potential solutions developed were also included in the questionnaire. Awareness programs to schools and local government officials were also conducted. A total of 66 individuals were interviewed in six Divisional Secretariats. Majority of the respondents did not have proper knowledge about crocodiles as reported in previous studies. Sand mining was found to be a major cause of the issue changing the river physically, geologically and chemically (18 %, n=66 as per respondents). 26 % believes that a sudden population rise as the main reason for recent attacks. 68.1 % (n=66) use the river throughout the day for all purposes (42 % (n=81 responses)). 36 % believe that croc watching tours will not benefit community. 26.2 % (n=126 responses) believed more crocodile exclusion enclosures must be built and19% (n=126 responses) proposed alternate water source as solutions. Majority (86%, n=66) believe that public showers are useful and (61 %, n=66) are willing to adopt a new lifestyle without the use of the river if an alternate water source is given. A list of short term and long term rational solutions were formulated based on this study. Each numbered according to its priority. Both long term and short term solutions must be implemented imminently.

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group
pp 252 - 254

Population assessment and status of salt water crocodiles (*Crocodylus porosus*) in Bellanwila- Attidiya Sanctuary, Attidiya, Sri Lanka

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Abstract

The study was conducted in a waterway within the Bellanwila - Attidiya Sanctuary. The canal was sectored in to two parts and was surveyed from Jan 2013 to April 2013 on randomly selected dates.. 31 individual sightings were recorded. 14 (45 %) and 17 (55 %) crocodiles were recorded in sections 1 and 2 respectively. The population density of crocodiles in the area is 5.3 (Based on the day maximum number of encounters were recorded: day 3, n=10) and the population density in Section one and two were 3.6 (n=4) and 7.79 (n=6) respectively. Average sightings per day were 6.2 day^{-1} (2.1hr^{-1}). Three (10%) hatchlings, one (3 %) juveniles, 2 (6 %) sub adults, 10 (32 %) adults and 15 (48 %) EO was recorded. 26 (84 %) were found in canals and five (16 %) in the lake. 15 (48 %) were found in shallow water near bank, six (19 %) was found in open waters and 10 (32 %) aquatic vegetation near bank.

Introduction

Two species of crocodiles: the Mugger or Marsh crocodile *Crocodylus palustris* Lesson, 1831 and the Saltwater or Estuarine crocodile *Crocodylus porosus* Schneider, 1801 are reported from Sri Lanka. The saltwater crocodile (*Crocodylus porosus*) is a highly threatened reptile in Sri Lanka existing in only a few locations that consists of proper habitat for it to thrive in. It is categorized as Endangered in the 2012 National Red List according to its distribution within the island (MOE 2012). It has only a few favoured natural habitats left, and presently most of these habitats are being cleared, altered and under pressure by human activities. The numbers of the saltwater crocodiles has been greatly reduced in Sri Lanka whereas it is more abundant in other parts of its range (de Silva, 2008). This reduction is mainly due to killing of crocodiles for its skin and mean, destruction of habitat and destruction of nesting sites.
Crocodylus porosus occur mostly in coastal areas such as Bentota, Negambo, Bolgoda, Muthurajawela, Matara, Kumana & Trincomalee. However, populations are found in Nawala and Etul Kotte (Deraniyagala 1939; Samarasinghe DJS. Pers.Obs). The present study reports the status and population of *Crocodylus porosus* within a selected area in the Bellanwila-Attidiya Sanctuary.

Study site

BAS is situated within the upper catchments of the Bolgoda river basin. The core study area is roughly 12 km x 0.5 km (nearly 372 ha), at a mean elevation of 0.6 m above sea level.
BAS area lies at the intersection of 6° 48'-52'N and 79° 52'-56' E (IUCNSL & CEA, 2006; Maduranga, 2005). This area is situated within the low country wet zone and has a tropical monsoonal climate (Gunatilleke & Gunatilleke, 1990). Mean annual temperature is approximately ~28o C and average annual rain fall for the study area is about 2800 mm (CEA / Euro consult, 1993). The study was conducted in a waterway within the Sanctuary. The canal was sectored in to two parts: Section one (1.11 km): Bellanwila - Attidiya Wild Life Department office (6˚ 50' 14.41" N 79˚ 53'28.61" E) to Attidiya Bridge (6˚50'40.46"N 79˚53'05.31"E); Section two (0.77 km): end of section one to 200 m away from Kawdana Bridge (6˚50'18.46"N 79˚52'45.57" E). Section one is relatively less exposed to human pressure than section two. Manmade structures such as houses, buildings are less encountered in section one,

Methodology

The two sections were surveyed from Jan 2013 to April 2013 on randomly selected dates. Eye shine surveys were conducted for five days (From 1930 h to 2230 h) and visual encounter surveys were conducted for four days during daytime. All surveys were conducted by foot, sampling both sides of the canal equally. Hatchlings <0.35, Juvenile 0.35-1 m, sub adult < 2 m, 2 m< as adults (Webb et al., 2010; Webb & Manolis 1989). Eyes only counts were recorded as EO. Habitats were divided into three: Canal, land and lake. Microhabitats were identified as: shallow water near bank, Open waters and among aquatic vegetation.

Results

31 individual sightings were recorded throughout the study period. 14 (45 %) individual sightings of crocodiles were recorded in section one and 17 (55 %) were recorded in section two (Figure 1) during the study period. The population density of crocodiles in the area was 5.3 km^{-1} (Based on the day maximum number of encounters were recorded: day 3, n=10). The population density in Section one 3.6 km^{-1} (n=4) and 7.79 km^{-1} (n=6) in section two. Average sightings per day were 6.2 day^{-1} (2.1hr^{-1}). Three (10%) hatchlings, one (3 %) juveniles, 2 (6 %) sub adults, 10 (32 %) adults and 15 (48 %) EO was recorded. 26 (84 %) were found in canals and five (16 %) in the lake (Figure 2). 15 (48 %) were found in shallow water near bank, six (19 %) was found in open waters and 10 (32 %) aquatic vegetation near bank (Figure 3). Eichhornia sp. was observed to spread throughout the canal mainly in section 1 during the last two days of the survey (Figure 4). A reduction of encounters was evident due to the spreading of water hyacinth (n=7, encounter rate: 1.4 day^{-1}). Several exist points of waste material (Unknown chemicals) from nearby factories were observed.

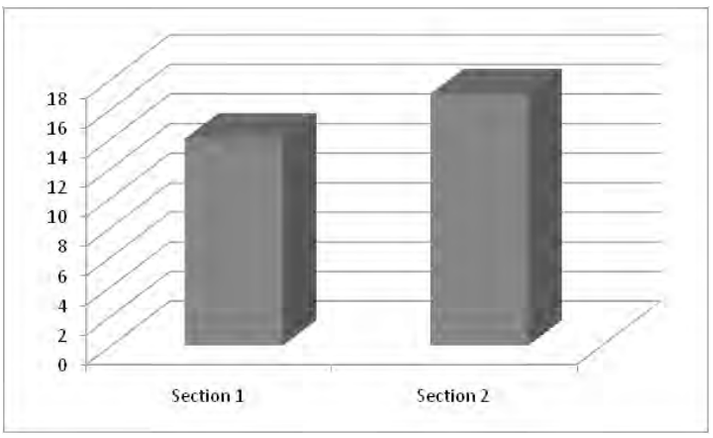

Figure 1. Total number of individuals recorded in Section 1 and 2.

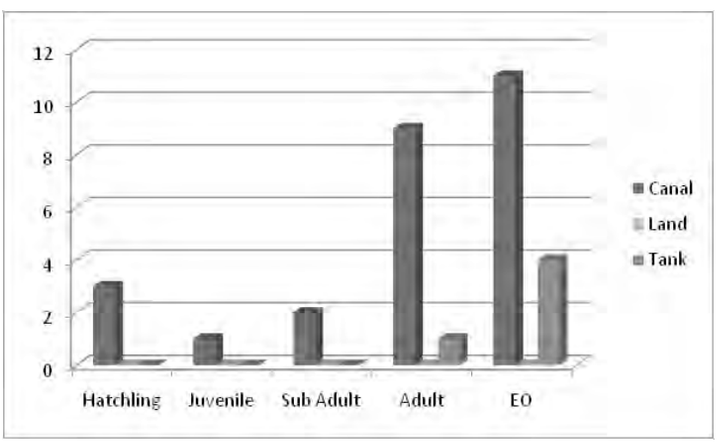

Figure 2. Habitat Selection and Age Class.

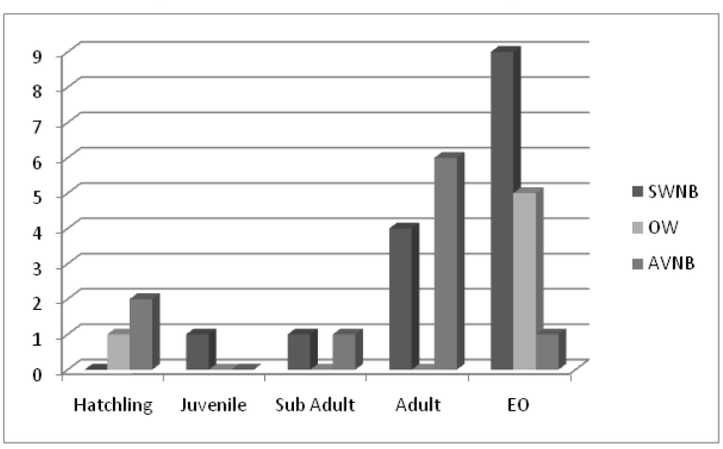

Figure 3. Micro Habitat Selection and Age Class. (SWNB: Shallow water near bank; OW: Open warers; AVNB: Aquatic vegetation near bank).

Discussion

BAS currently under massive anthropogenic pressure due to recent urban development strategies, unauthorized construction of houses, garbage dumping together with dumping of hazardous waste by nearby factories to the canal and the spread of the invasive aquatic plant water hyacinth (Figure 5 & 6). The population density in Section two is much higher when compared with section two 7.79 km^{-1} (n=6) and 3.6 km^{-1} (n=4) respectively. Section two has more anthropogenic pressure than section relatively, but the canal expands in with and one area is regarded as a high security zone, yet there are signs of dumping of waste material in to the canal.

Although crocodiles are highly adaptive to most environments, the amount of chemicals released into the canal, low flowing rate of water thus accumulating of hazardous chemicals could have a bad effect towards the crocodiles inhabiting this area. These chemicals and other toxins mix into the water especially at the beginning of the monsoon season and many large fish and water monitors are often observed dead. As crocodiles are also scavengers they could be devouring these dead carcasses, which could in return pose adverse health risks.

It is recommended that a proper mechanism is developed to remove water hyacinth periodically, and stop dumping of garbage and other hazardous waste material into the canal immediately. This could put pressure on the current population of crocodiles and suppress their distribution further inland to Weras ganga and Kiri Matta area where crocodile are present. Another threat identified was fishing using nets by villagers. Although humans do not use the canal for bathing purposes, they use the canal to harvest *Ipomoea aquatica in section one.* These people could face a threat by crocodiles.

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Literature Cited

01. CEA/Euroconsult, 1993. *Wetland site report and conservation management plan, Bellanwila-Attidiya Marsh*. Wetland Conservation Project: 83

02. *Deraniyagala, P. E. P. 1939. The Tetrapod reptiles of Ceylon. Vol.1 Testudinates and crocodilians. National Museum, + 412*

03. *de Silva, Anslem. 2008. The status of the Saltwater crocodile (Crocodylus porosus) inhabiting the Nilwala River, Matara District and its impact on the community. IUCN/WWF/American Red Cross Partnership. 34 pages (unpublished report)*

04. Gramentz, D. (2008). The distribution, abundance and threat of the saltwater crocodile, Crocodylusporosus, in the Bentota Ganga, Sri Lanka. http://iucncsg.org/ph1/ modules/Publications/reports.html.

05. Gunatilleke, I. A. U. N. and C. V. S. Gunatilleke, 1990. Dristribution of floristic richness and its conservation in Sri Lanka. Conservation Biology, 4 (1): 21-31.

06. IUCNSL and CEA, 2006. National Wetland Directory of Sri Lanka. IUCN Sri Lanka, Colombo: 342.

07. Maduranga, H. G. S. 2005. Ichthyofauna of Bellanwila-Attidiya Sanctuary and its environs in Colombo, Sri Lanka. Tigerpaper, 32 (1): 26-32.

08. MOE 2012. The National Red List 2012 of Sri Lanka; Conservation Status of the Fauna and Flora. Ministry of Environment, Colombo, Sri Lanka. Viii + 476 pages.

09. Webb, G. and S.C. Manolis 1989. Crocodiles of Australia. 160 Pages

10. Webb, G.J.W., Manolis, S.C. and Brien, M.L. 2010. Saltwater Crocodile Crocodylus porosus. Pp. 99113 in Crocodiles. Status Survey and Conservation Action Plan. Third Edition, ed. by S.C. Manolis and C. Stevenson. Crocodile Specialist Group: Darwin

Figure 4. Study Area.

Figure 5. Water hyacinth spread throughout the study area.

Figure 6. Waste material and garbage dumped to the canal.

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN SSC Crocodile Specialist Group
pp 255 - 256

Preliminary study on attitudes, knowledge and practices (KAP) of villagers towards conservation of crocodiles (*Crocodylus palustris*) in Ethimale Tank of Uva Province

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Abstract

A survey was formulated to study peoples' attitudes, knowledge, practices and risk perceptions towards survival of crocodiles *(Crocodylus palustris)* in the Ethimale tank at Moneragala district. A pre-tested structured questionnaire was used to collect data from 47 residents including fisherman and villagers, those who utilize the reservoir daily. The questionnaire included information on the crocodiles, their habitat and behaviour, importance and current practices of villages which affects survival of crocodiles. Knowledge and attitude were measured using knowledge and attitude indices. Data analysis was carried out by Microsoft Excel. As observed by the villagers, the number of crocodiles drastically reduced after 1983, with the damage occurred to the tank bund. Villagers practiced mass killing of the crocodiles and some were migrated to surrounding tanks in Ethimale. Intentional killing of yearlings and trapped crocodiles in fish nets and destruction of eggs to control their population, use of floating nets for fishing that attract crocodiles and illegal consumption of crocodile eggs and flesh were identified as the major threats for the survival of the crocodiles at present. Major problem for the villagers is the economical damage caused by crocodiles, by feeding on the fish catch and damaging the fishing nets. There are no incidences on direct crocodile attacks to human. Moreover, it was noted that the villagers possess moderate awareness on crocodiles including their behavior, measures to escape once a crocodile had attacked, and their importance as a part of the ecosystem. Around 40% provided positive responds on crocodile based eco-tourism, if enough protective measures are followed. Though, the need for conservation of the crocodiles is identified by the villagers (71%), their precedence for living does not allow practicing conservation measures. Hence, it can be concluded that crocodiles are under threat in the area and conservation initiatives need to be taken immediately to prevent them from extinction.

Introduction

The largest wild mugger crocodile (*Crocodylus palustris*) population inhabits in Sri Lanka, especially in inland reservoirs, tanks, river (Stacy and Whitaker, 2000). However, habitat destruction and fragmentation due to population growth leads to reduce the mugger crocodile population from their natural habitats. Ethimale reservoir which located in Moneragala district is known to occupy considerable number of mugger crocodiles. Area of the reservoir is 1850 acres and used for inland fisheries extensively. Therefore, it may cause a threat to the survival of crocodiles which inhabit the reservoir. Hence, this study was formulated to study peoples' attitudes, knowledge, practices and risk perceptions towards survival of crocodiles (*Crocodylus palustris*) in the Ethimale tank at Moneragala district.

Methodology

Knowledge, Attitude and Practices (KAP) of respondents towards crocodiles were assessed using a pre-tested structured questionnaire. Data were collected from 47 residents including fisherman and villagers, those who utilize the reservoir daily to understand the nature of interaction of residents with crocodiles.
Knowledge and attitude were measured using knowledge and attitude indices. Knowledge was measured by collecting information on the crocodiles, including approximate size, breeding pattern, their habitat, behaviour, importance and folk believes. Current situation of human crocodile conflict (number of crocodile attacks, damage incurred and reaction towards offending crocodile) and practices of villagers which aggravate the conflict were assessed based on the observations and information gathered from respondents. Attitude of the respondents were assessed based on the solutions suggested by them to solve the human crocodile conflict. Furthermore, their attitude on the necessity of conservation initiatives for crocodiles was evaluated. Finally, the potential to use crocodile based ecosystems for eco-tourism was studied. Data analysis was carried out by Microsoft Excel.

Results & Discussion

According to the observations of the respondents, there are around 70 to 100 crocodiles inhabit the reservoir and average length of an adult crocodile is 6-7 feet. Their habitat is shallow water less than 10 feet. Respondents have observed the crocodiles on the ashore specially during morning (6-7 a.m.) and evening (6-8 p.m.). Furthermore, they migrate away from the human territory during November to February where the highest rainfall was experienced in this area. Breeding is taking place predominantly during the dry season (August) and they lay eggs in the sandy tank bunds. People have seen foot long hatchlings during September and October. Major predators for hatchlings are *Varanus bengalensis* (Monitor) and *Varanus salvator salvator* (Water monitor).

Among the respondents, the major group who interact with the crocodiles were fishermen, representing 80% of the sample. Though, there are no incidences on direct crocodile attacks to human, economical damage caused by crocodiles (by feeding on the fish catch and damaging the fishing nets) was identified as the major problem for the fishermen. Conversely, fishermen use floating nets for fishing which attract crocodiles to the fish catch aggravating the conflict. As observed by the villagers, the number of crocodiles drastically reduced after 1983, with the damage occurred to the tank bund, due to migration and mass killing of crocodiles. At present, intentional killing of yearlings and trapped crocodiles in fish nets, illegal consumption of crocodile eggs and flesh were identified as the major threats for survival of them and consequently the population is declining day by day.

Though, the need for conservation of the crocodiles is identified by the respondents (71%), their precedence for living does not allow practicing conservation measures. However, 60% of fishing community suggested that immediate actions should be taken to solve the problem and one of their major suggestions was capturing and translocation (Figure 1).

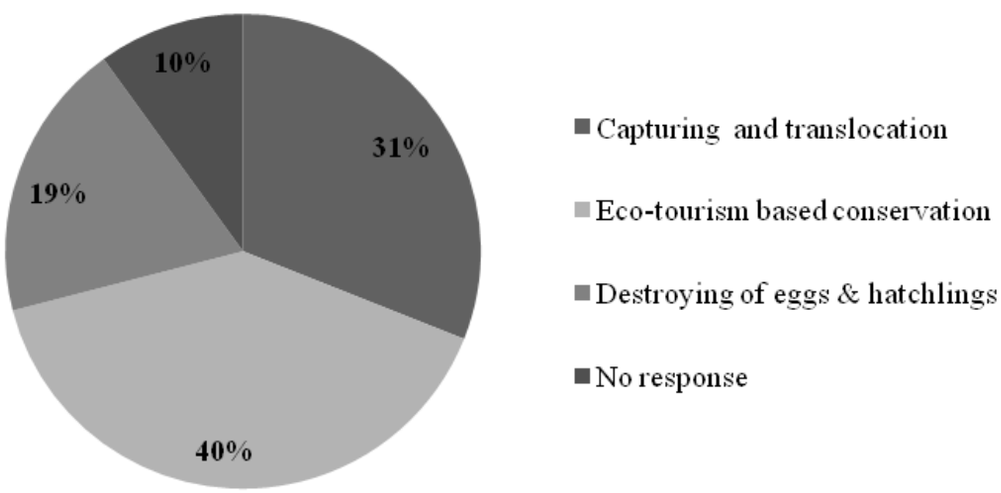

Figure 1: Proportion of responses to solve the human crocodile conflict in Ethimale tank

Around 40% provided positive responds on crocodile based ecotourism, if enough protective measures are followed. Since, both parties are mutually benefitted, this can be identified as a potential measure to solve the human crocodile conflict.

Conclusion

It can be concluded that crocodiles in Ethimale tank are threatened by the human activities, and conservation initiatives need to be taken immediately to prevent them from extinction. Since, the villagers possess a positive attitude towards conservation of crocodiles there is a possibility to implement a conservation strategy.

References

01. Stacy, B.A. and Whitaker, N. (2000). Hematology and Blood Biochemistry of Captive Mugger Crocodiles (*Crocodylus palustris*). *J. Zoo. Wildlife. Med.* 31(3): 339-347.

Preliminary observations of the status of crocodiles and peoples attitudes towards crocodiles in the northern province of Sri Lanka

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Most of the northern parts of Sri Lanka are poorly investigated for crocodiles during the past half a century due to over 30 years of civil conflict in the north of the country. However, there are reports of the presence of the mugger dating back to 1852. As such, a study was designed to investigate the status of crocodiles inhabiting the Northern Province which is a part of the ongoing crocodile survey of Sri Lanka. The Northern Province consists of 5 administrative districts namely Jaffna, Kilinotchchi, Mullativu, Vavuniya and Mannar. Each district was visited several times and preliminary investigations were carried out from May 2010 to January 2013. These investigations were carried out first to check for crocodiles and then to assess the knowledge and attitude of people regarding crocodilians by administered a structured questionnaire. The presence of crocodiles were checked by investigating the scats, foot prints, drag marks during the day and night counts using 'eye shine' technique. Approximately ten tanks and part of the Jaffna estuary were investigated in Jaffna of which evidences such as foot marks, osteoderms and scats were collected. During the survey period we did not come across any crocodile bite victims in Jaffna district. However, in Vauniya several crocodile bite victims were interviewed and mugger burrows were also observed in two tanks. In Mannar, muggers including both live and killed specimens were observed. Examinations of exhumed adults from Mannar island indicated people do not eat crocodile flesh in Mannar island, where as around Giants tank many crocodiles have been killed for flesh. In Jaffna out of 71 people interviewed, 86% had no idea of the importance of crocodiles, 21% aware of crocodiles and said crocodile killing were done because of attacks and 14% said they would not support conservation initiatives towards crocodiles. Our preliminary investigations suggest that there is an appreciable mugger population in many unexplored areas of the Northern Province. However because of the resettlement activity in this part habitat reduction and crocodile kills are noticed. Thus it is felt that the people must be informed about the important ecological roles played by crocodiles as well as to install crocodile exclusion enclosures for the people to carry out their routine activities.

Using traditional knowledge to minimize human-crocodile conflict in Sri Lanka

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With the exponential increase of human populations due to large--scale agricultural and human settlement projects over the past half century, the number of humans and livestock using natural water bodies in the dry zone of Sri Lanka has increased significantly. Water bodies in these areas are also inhabited by mugger crocodiles (*Crocodylus palustris*)- the top predators of the ecosystem. This sharing of an essential, but a limited resource has resulted in an increase of 'Human-Crocodile Conflict' (HCC).

Traditionally (and till present day), Crocodile Excluding Enclosures (CEEs) have been used by people in the southern wet zone of the island where humans frequently use waters inhabited by saltwater crocodiles (*C. porosus*). CEEs are simple devises where three sides are fenced with wooden poles. However (surprisingly), CEEs are not in use in most parts of the dry zone where large populations of muggers exists and pose a serious medical concern through attacks (minor to grievous, including deaths) annually.

This study fulfilled three objectives: 1) it identified three regions covering over 10 villages with a considerable HCC and, with the help of the communities, introduced and installed CEEs to physically segregate the two components humans and muggers; 2) undertook two 'Knowledge Attitude and Practice' surveys, one pre construction and the other six months post-construction (100 participants each) to measure the success and understand limitations; and 3) conducted concurrent awareness programmes to upraise the understanding of crocodiles among the lay public.

The study indicates that building physical barriers to segregate the two components and concurrent development of a positive attitude towards crocodiles through awareness programmes are effective actions in reducing the HCC in Sri Lanka. The results show that there is a significant increase in the frequency and duration of use of water resources by villages and also a positive attitude change towards crocodiles. No crocodile attacks on humans or killing of crocodiles by humans were reported from the areas since the CEEs were installed, where as three crocodile attacks (one fatal) and at least seven crocodile deaths have been reported the year before.

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN SSC Crocodile Specialist Group
pp 258 - 260

A view on saltwater crocodile *(Crocodylus porosus*) captured from anthropogenic habitats in western province, Sri Lanka

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Abstract

Over the past few years there has been a dramatic increase in the media attention to humans and domestic animals that have been attacked by Salt water crocodiles. Although it has not received equal attention, many Salt water crocodiles have also been killed by humans. In-between there are many instances that crocodiles were captured from the residential areas and relocated to suitable habitats with the involvement of the Dept. of Wildlife Conservation (DWC) and other conservationists. Among the 16 specimens captured by the DWC during the past 2 years, 14 were males. Among these animals, there was one instance where the crocodile died due to the wounds caused by a hook, which was used to hunt the animal using bait by the locals. There have been several reports of this occurring elsewhere, and the animals have died before rescue was possible. The other crocodiles that were captured were released back to the National Parks such as Yala and Bundala and to sanctuaries such as Muthurajawela.

Introduction

The Saltwater Crocodile (*Crocodylus porossus*) also known as Salties or Estuarine crocodiles. The Salt water crocodile is one of the 23 species belonging to family Crocodylidae. Globally distributed in a wide area, this species is considered as the largest species of the Crocodiles (Deraniyagala, 1936,Ross,1989; Alderton,1991,). It is also the world's largest living reptile in terms of mass. Adult males can reach sizes of up to 6 meters (20 feet) with possible reports of exceptionally rare individuals of nearly 7 metres (23 feet). However, the largest confirmed individual was measured as 20.7 feet (6.3 metres) taking into account partial tail loss (Whitaker, R & Whitaker, Z: 1998)

They are recorded in South and South-East Asia, Northern parts of Australia, Philippine Islands, Papua New Guinea, Solomon Islands, Vanuatu and Palau (Alderton,1991; Stuebing et al., 1994). There are many instances that even 9m crocodiles have also been reported in the latter part of the 19th century.

Female Saltwater Crocodiles reach sexual maturity at lengths of 2.2 to 2.5 m (10 to 12 years old). Males mature later (3.2 m, at around 16 years old). Females on average lay 40 to 60 eggs (this can range from 25 to 90) in mound nests made from vegetation (usually grasses and vines) and mud. Breeding territories are usually established along tidal rivers, creeks and freshwater areas. These are normally constructed between the months of November and March during the wet season, but this varies slightly geographically. The mound helps to insulate the eggs from temperature extremes, hides them from predators, stops them from dehydrating, and also serves to raise the eggs above the ground to minimize the risk of flooding.

Background

Within the last few years there has been many instances that the humans, live stocks and dogs were attacked by the Salt water crocodiles. It was revealed by a survey done in 2010 associating more than 100 water bodies that about 130 persons were attacked with 35 fatalities. About 80 per cent of them were attacked while they were bathing and washing clothes in tanks. Conversely over 50 crocodiles were killed by the locals in revenge and as a measure to prevent future attacks. In 2011, there had been 25 deaths due to crocodile attacks, in the island but in 2012, it was very few. However both parties of crocodiles and humans are affected by these incidents.

Western province, in Sri Lanka is the most urban region and still records crocodile in residential areas each year. All these records are of the Salt water crocodiles. The Dept. of Wildliffe conservation and other groups of concervationalists involve in capturing the crocodiles with the help of the public . It is a good trend that the public is engaging in reporting the authorities and even capturing them unharmed to hand over to them. However it is still reports that few crocodiles killed by humans using baits.

Earlier there are incidents that the crocodiles were shot to death. Since the leagal issues came in to paly the method of killing the crocodiles is changed. The most common way is using a dead dog or beef as the bait. There was one instance reported, that two hooks joint as a "Y" with a cable to hunt the crocodile. When the crocodile got caught, it was managed to free itself from one hook by pulling. The wounded crocodle was captured by the DWC, and trired to remove the swallowed hook. Unfortunately the crocodile died due to septic wounds and it was revealed in the post motum, the internal organs such as the lever and the intestines were torn while the crocodile was trying to escape. Other method of killing crocodiles are poisoning them, or beating them to death after capturing them using traps.

Captured Areas

Ten individuals were captured from Weres ganga (canal) and other water bodies attached to it. Three crocodiles were captured inside the houses and which were also closer to the canal. There was one instance that the crocodile was caught in fishing net and another was found stucked in a drain (Chart:01) , (Map:01)

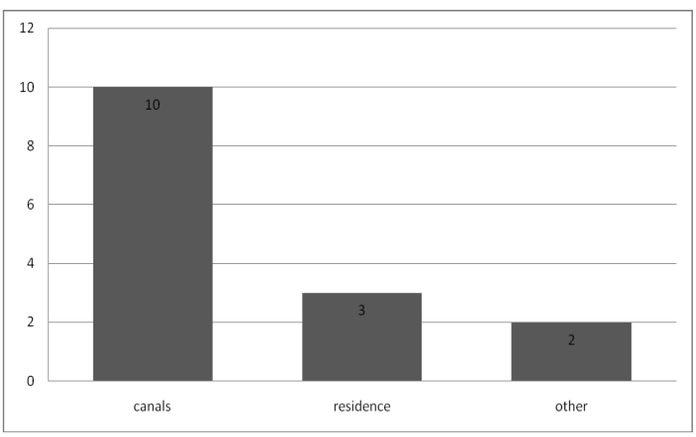
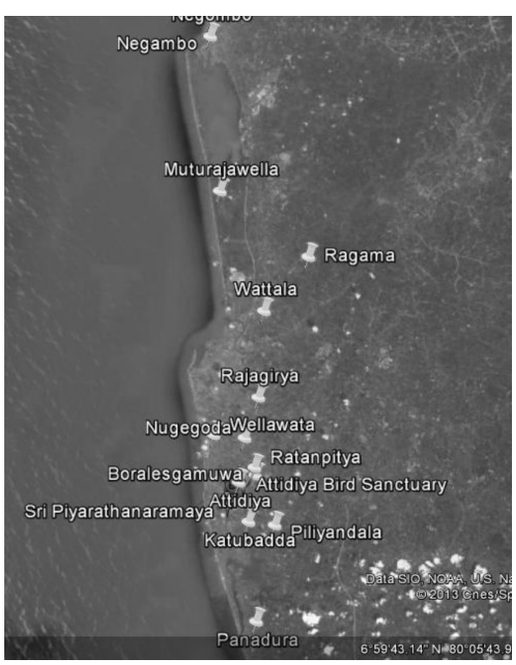


Chart 01 : The Habitat Types That The Crocodiles Were Captured.

From the 16 specimens those were captured and released, 14 were males and only 2 were females. This situaton can be justified as a territory issue since Salt water crocodile is a very terrestrial species. Sub adults males may be chased away by the larger males and due to scarcity of food sources; they may tend to attack humans and livestocks.

Suggestions

Relocating the animal is not the ideal solution to solve the human-crocodile conflict. It only brings out a temporary releaf to the affected people. The Western Province of Sri Lanka belongs to the low land wet zone. If an animal is relocated, that new habitat also should belong to low land wet zone. Muthurajawela is a suitable habitat for Salt water crocodiles. Since the land area of Muthurajawela is not sufficient enough to accommodate many larger crocodiles, due to territory problems it is not the first option of the DWC to release the crocodiles. There is a need of a proper relocation area for the captured crocodiles. Not only a crocodile's sanctuary, but also a rehabilitation center for crocodiles also needed. . The distance from the capturing area should also be considered when transporting the crocodile. Many crocodiles captured had wounds and were treated in the National Zoo. Some of the crocodiles released were handicapped ones, which made it more vulnurable for them to survive in the wild. Specially Yala and Bundala, the National parks situated in the dry zone, has a very large population of Marsh crocodiles (*C. palustris*). On the other hand, Bolgoda river and Muthurajawela marsh lands can provide suitable habitats, but urbanization and the land size restrict the number of Salt crocodiles can live in the area (Chart:02).



The locations which the crocodiles were captured. (Map :01)

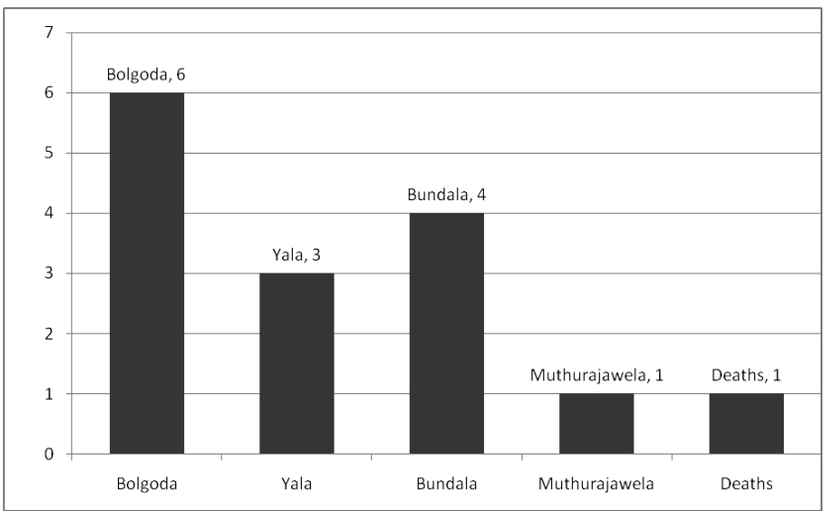


Chart 02: The Locations The Crocodiles Were Released

Since there had not been proper researches done on the home range of male and female crocodiles it is essential that these kind of investigations to be done. It is important using modern tracking techniques for this purpose. Tagging of the captured and relocated crocodiles can be easilly done .If those individuls can be monitored valuable informatin can be gatherd about the behavior of these animals, or whether they were really able to survive in their new habitat. More data is needed of both sexes, not only the captured animals, but also the other crocodiles in wild habitats and of different sizes.

Acknowledgment

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References

1. De Silva, A.(2008) The status of the Saltwater crocodile (Crocodylus porosus) inhabiting the Nilwala River, Matara District, Sri Lanka and its impact on the community project report For IUCN Sri Lanka

2. Deraniyagala, P.E.P. (1930): The Crocodiles of Ceylon. Spolia Zeylanica.

3. Deraniyagala, P.E.P. (1939): The Tetrapod Reptiles of Ceylon. Vol.I. Testudinates and Crocodilians. Colombo Museum Natural History Series. Ceylon Journal of Science.

4. Gramentz, D. (2008): The distribution, abundance and threat of the saltwater crocodile, Crocodylus porosus, in the Bentota Ganga, Sri Lanka

5. Santiapillai,C.and Wijeyamohan,S. (2004)Rediscovery of Crocodiles in the Jaffna Peninsula, Sri Lanka. Crocodiles Specialist Group Newsletter.

.6 Whitaker, R & Whitaker, Z: (1998) Crocodile Fever Wildlife Adventures in New Guinea.

Challenges for current Red List assessments for Crocodilians

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The IUCN Red List is the definitive global evaluation of threatened species. Most crocodilian Red List assessments date from 2002 and re-assessment of the status of many crocodilians is overdue. Species categories and criteria are based on IUCN Red List categories and criteria version 3.1 (2001) and conducted by teams of CSG species experts coordinated by the Red List Authority. Since 2012, new assessments have been completed on two species and are underway or planned for six more. The completed assessments must be reviewed by CSG members and steering committee and approved by the Chairman, then submitted to IUCN for inclusion in the updated list.

Changing crocodilian taxonomy driven by new genetic and morphology studies provide a challenge for assessments. Recent work indicates a number of currently recognized species probably include cryptic species not previously recognized. There is sound evidence that the populations of *Crocodylus niloticus* occurring in western and central Africa are distinct at the species level (Hekkala et al 2011). *Osteoleamus* is now thought to include *O. tetraspis*, a revived *O. osborni* and possibly a third unnamed taxon (M. Eaton pers comm. and in prep.). *Mecistops cataphractus* appears to be two taxa (M. Shirley pers comm. and 2013) and the division of *C. noveaeguineaea* first suggested by Phil Hall and Andy Ross (Hall 1989) is supported by genetic information (Gratten 2003). Doing global Red List assessments of currently recognized species may obscure or conflate different conservation status of cryptic taxa. However, current legal protections such as CITES and national laws may be destabilized by premature changes of unrecognized or informal taxa. To address this, the CSG Red List authority is in discussion with species experts, taxonomic experts and Red List staff to ensure orderly modification of the list of species for Red Lists assessment. To begin, we have added the new, west African *Crocodylus* to enable drafting an assessment of that taxon separate from *C. niloticus* of eastern and southern Africa.

Additional challenges to assessments are generated when the uncertainty of data allow different interpretations of status. For example, a recent assessment of *C. palustris* proposed its Vulnerable status based upon recent decline. However there is uncertainty about the population size (mature adults worldwide). If that number is less than 2,500 and the species is thought to be in decline- it might qualify for Endangered under criterion C 2 a i, However if they are not declining or if the adults population exceeds 2500 then the status is Vulnerable A 2acd (IUCN 2001). Resolving this uncertainty by a consensus 'best estimate' of population numbers will allow finalization of this assessment.

Assessments undertaken since the last CSG Working Meeting 2012 are summarized here:
Crocodylus siamensis **CR-Critically Endangered A2 cd**. Reduction in population size ≥80% over the last three generations (75 years) inferred due to c. decline in area of occupancy and d. actual levels of exploitation.
Tomistoma schlegelii **VU A 2 c**. **Vulnerable** Populations have been reduced, by over 30% in the past 75 principally due to continuing loss and fragmentation of swamp forest and many documented populations are small, fragmented. The change to Vulnerable reflects a more accurate assessment based on survey data which was not available at the time of the first assessments (CSG 2000).
Crocodylus mindorensis **CR A2 c d**. **Critically Endangered**, declines in the last 75 years. In final review**,** *Crocodylus palustris* **VU or EN??** -. Under review**,** *Crocodylus niloticus* (East and southern Africa) in progress*, Crocodylus sp. Nov* (west and central Africa) in progress*, Osteoleamus tetraspis* in progress*, Mecistops cataphractus* in progress

References

1. Gratten, J.. 2003. The molecular systematics, phylogeography and population genetics of Indo-Pacific crocodiles. PhD Thesis University of Queensland:222 Pp.
2. Hall, P. M. Variation in geographic isolates of the New Guinea crocodile (*Crocodylus novaeguineae* Schmidt compared with the similar, allopatric, Philippine crocodile(*C. mindorensis* Schmidt). 1989. Copeia (1):71-80
3. Hekkala, Evon, Matthew H. Shirley George Amato, James D. Austin, Suellen Charter, John Thorbjarnarson,Kent A. Vliet, Marlys l. Houck, Rob Desalle, and Michael J . Blum. 2011. 2011 An ancient icon reveals new mysteries: mummy DNA resurrects a cryptic species within the Nile crocodile. Mol. Ecology. doi: 10.1111/j.1365-294X.2011.05245.x
4. IUCN. (2001). IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission, IUCN Gland, Switzerland and Cambridge, UK; ii+30pp.
5. Shirley H. M. 2013. Hierarchical processes structuring crocodile populations in Central Africa. Ph D Thesis University of Florida

Captive populations of Tomistoma in Taiwan

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There are 77 individuals (18 males and 59 females) of Tomistoma,*Tomistomaschlegelii*, in seven different units in Taiwan. Among them, Longqun Crocodile Farm, Chaiyi has largest captive population including 15 adult males and 28 adult females. The body size of Some males Tomistoma in Longqun Crocodile Farm may exceed six meters, maybe the largest captive individuals in the world. Taipei Zoo signed an agreement with Longqun Crocodile Farm to cooperate the conservation of Tomistoma. We successfully sampled 12 individuals and analyzed their genetic diversity. Five haplotypes were found among 12 samples, at least three haplotypes are different from the previous studies. The serious problem of captive population of Tomistoma in Taiwan is ageing, most of them are near 30 years old.

Plastination of crocodiles for veterinary education

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Historically taxidermed specimens were used to demonstrate reptilian morphology. In the 1970s plastination techniques to replace tissue fats and water by liquid curable polymers were developed by Gunther von Hagens. Once hardened, these specimens retain the anatomical characteristics of the original specimen but do not decompose or smell. Consequently we routinely use plastinated specimens to teach reptilian gross anatomy. To plastinate small crocodilians we follow the methodology based on using the specifically developed silicon polymer Biodur S10 (von Hagens, 1985). Here specimens are kept in fixative for at least four weeks to ensure tissue stabilization. This is followed by dehydration using ascending concentrations of acetone at -25°C to remove tissue water. Next, fats are removed by solvents, acetone or methylene chloride, at room temperature for a short time. Then the specimen's volatile solvents are replaced by submerging the specimen in a miscible curable silicon polymer (S3) bath under a vacuum starting at 7.5 mm Hg which is increased slowly over 3-4 weeks to 0.5 0 mm Hg. A subsequent fixation period of >24 hours at standard pressure for tissue relaxation is recommended. The specimen is removed from the silicone bath and allowed to slowly warm up to 25°C with as much silicone inside the specimen as possible to limit shrinkage. Minor changes to limb positioning can be done at this stage. Subsequently, the specimen is placed in a curing gas (S6) atmosphere to facilitate polymer reactions and ultimate hardening of the specimen. Regular removal of excess silicone is necessary. Drying in a closed tank afterwards is essential. Overall we have found that plastination produces excellent robust specimens that students can handle with little chance of damaging them.

Teaching anatomy and histology of crocodilians

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In Europe and North America current veterinary graduates have a broader range of employment opportunities, many of which include wildlife, than ever before. This has been driven, in part, by the marked increase in the personal ownership of exotic pets of which reptiles are a significant component. The demands for excellent veterinary care for this diverse group of animals had grown commensurately. Consequently the need for the inclusion of basic anatomical and histological training of non-domestic animals including reptiles, birds, amphibia and fish has grown dramatically for our current veterinary medicine undergraduates. To accommodate this demand our Institute of Veterinary Anatomy at the Freie Universitaet in Berlin, has introduced a compulsory course for our undergraduates to study the functional morphological characteristics of these groups of animals including crocodilians. The course curriculum involves gross anatomical studies of skeletal and plastinated specimens as well as histological specimens prepared by our institute. The characteristics of the crocodilian musculoskeletal, digestive, urinary and reproductive systems are each covered in depth. Details of cardiovascular and pulmonary systems, sense organs, skin, hematology, as well as radiography are also explored. Powerpoint presentations are based on only a few books and journal articles on anatomy and histology of crocodilians as such literature is limited. A few websites provide additional information on specific aspects of crocodilian anatomy. Whenever possible we endeavour to have our students gain experience with live crocodilians held in veterinary clinical institutions as well as by excursions to zoological institutes.

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pp 264 - 266

Chemical *c*omposition of Siamese Crocodile (*Crocodylus siamensis*) egg yolk

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Abstract

The 23 unfertilized crocodile eggs were collected from captive mature female Siamese crocodiles. The yolks were separated and freeze-dried before analysis of their chemical composition, including fiber, fatty acids, amino acid profile and the inorganic substances as potassium, phosphorus, selenium, vitamin-D3, and vitamin-E. The results of chemical composition were discussed. The fresh and freeze-dried egg yolks were studied for their protein patterns compared with hen and duck egg yolks. These protein samples were separated by SDS-PAGE in condition that containing beta-mercaptoethanol reducing agent. The optimal concentration of polyacrylamide in the separating gel was 7.5% (w/v). The SDS-PAGE protein pattern of crocodile egg yolk was different from hen and duck egg yolks. In addition, there was no difference in protein pattern between the fresh- and freeze dried- crocodile egg yolks. The crocodile egg yolk contained major proteins in 233, 110, 88, 78, 66, 47 and 35 kDas. These findings can be useful as crocodile egg database for sustainable uses and value added as functional food in the future.

Introduction

Siamese crocodile (*Crocodylus siamensis*) is an important economic animal in Thailand. The crocodiles lay high eggs per year which 40% are unfertilized eggs. Only 10% of this unfertilized egg was consumed. In order to evaluate the potential use of unfertilized Siamese crocodile eggs as a source for human and animal food products, their yolk fraction was studied on chemical composition and protein pattern. The data from this study may be guide lined for value adding of crocodile egg in supplementary or functional food industry.

Materials and Methods

Egg samples: Twenty three of captive Siamese crocodile (*Crocodylus siamensis*) unfertilized eggs were collected from Rungtaweechai Crocodile Farm, Don Toom District, Nakhonpathum Province, Thailand. The three of hen (chicken) eggs and duck eggs which purchased from Luang Suwan Vajokkasikij Egg Farm, Kasetsart University and a supermarket (Tesco Lotus Supermarket, Nontaburi branch, Thailand), respectively, were used in protein pattern analysis. The eggs were kept at 4°C in a refrigerator until used.

Egg yolk preparation: The eggshells were broken by hand, the white fraction was manually removed and the yolk was collected into microtubes using syring. These yolk fractions were prepared in two parts (fresh and freeze-dried parts) for protein pattern analysis. The remaining of crocodile egg yolk was weighted and then freeze-dried using freeze- dryer (Lyomaster, USA). After drying, the dried crocodile egg yolk was weighted, kept in sterile container and stored at 4°C for its chemical composition analysis.

Chemical composition analysis: The freeze- dried crocodile egg yolk was determined for its chemical composition as following. The total carbohydrate, protein (factor 6.25), saturated fatty acids, unsaturated fatty acids and cholesterol were examined by principle analyses of Thai Compendium of methods for food analysis, 1st ed. 2003. The tested inorganic substances as potassium, phosphorus, selenium, calcium, vitamin-E, -D3 (by principle analyses of Thai Compendium of methods for food analysis, 1st ed. 2003) were determined. The amino acid profile was analysed by Gas Chromatography/ HPLC (In house method based on J. Assoc. Off. Anal. Chem. Vol. 72. No.6. 1989)

Protein pattern analysis: Hen yolk (HY), Duck yolk (DY), Crocodile yolk (CY) and Freeze-dried CY (CYF) were homogenized with a homogenizer (Omni, USA.) at low speed for 30 seconds. The homogenates were diluted (1:100) with water and aliquot for Sodium Dodecyl Sulfate-Polyacrylamide Gel Electrophoresis (SDS-PAGE) - sample buffer

containing beta- mercaptoethanol reducing agent. SDS-PAGE was used for protein separation with separating gels (7.5%) and stacking gels (4%) at a constant current of 20 mA using a Compact-PAGE apparatus (Atto, Japan) followed by Coomassie Brilliant Blue R250 (CBB) staining. The protein patterns were recorded by gel document system (Gel Doc XR System, BioRad., USA). The protein band molecular weight was determined and compared using Quantity One 1-D Analysis Software. (BioRad, USA).

Results and Discussion

The mean width and length in centrimeter of Siamese crocodile eggs used in this study were 4.67 and 7.94, respectively. In addition, the mean weight of crocodile eggs yolk was 61.47 grams. The chemical composition of freeze- dried crocodile yolk was shown in Table 1. The high amount of vitamin- E and phosphorus were found in Siamese crocodile egg yolk (14.11 mg/100 g and 1,209 mg/100 g, respectively). The CY has high nutritive value more than hen egg yolk such as Oleic acid (HY~10.78 g/100g sample) Vitamin D3 (HY~5.4 ug/100g sample) and Glutamic acid (HY~1970 g/100g sample) (Mamara and Donald, 2003). But the CY has higher cholesterol than hen yolk (424 mg/100g) (USDA nutrient database, 2007). Amino acid profile of the yolk tested by Gas Chromatography/ HPLC was shown in Table 2. The top five amounts of amino acids were Glutamic acid (4665.37 mg/100g), Serine (4062.57 mg/100g), Aspartic acid (3595.95 mg/100g), Leucine (3247.37 mg/100g) and Arginine (2349.82 mg/100g), respectively. Amino acids in the least three amount were Tryptophan (495.07 mg/100g), Methionine (832.36mg/100g) and Cystine (852.29 mg/100g), respectively.

Table 1. The chemical composition of Siamese crocodile egg yolk

Substance	Amount	Unit
Carbohydrate	9.61	%
Protein	43.78	%
Cholesterol	855.57	mg/100g
Unsaturated fatty acid		
Palmitoleic acid (C16:1)	2.02	g/100 g
Oleic acid (C18:1,cis-9)	12.57	g/100 g
Linoleic acid(C18:2,cis)	5.61	g/100 g
Erucic acid (C22:1)	0.50	g/100 g
Docosahexaenoic (C22:6n3)	0.07	g/100 g
Saturated fatty acid		
Myristic acid (C14:0)	0.15	g/100 g
Palmitic acit (C16:0)	10.19	g/100 g
Stearic acid (C18:0)	1.88	g/100 g
Fiber		
Insoluble Dietary Fiber	32.71	%
Soluble Dietary Fiber	1.80	%
Dietary Fiber	34.51	%
Potassium	485.45	mg/100 g
Phosphorus	1,209	mg/100 g
Selenium	0.47	mg/100 g
Vitamin- A	14.11	mg/100 g
Vitamin- D3	87.38	mg/100 g

The crocodile egg yolk was determined for it protein pattern by SDS-PAGE in the separating gel was 7.5% (w/v). The results demonstrated its protein (CY/ CYF) pattern was different from hen (HY) and duck (DY) egg yolks (Figure 1). However, the protein patterns between the fresh- and freeze dried- crocodile egg yolks were not difference. The crocodile egg yolk contained major proteins in 233, 110, 88, 78, 66, 47 and 35 kDas. Chicken egg yolk presents protein bands at 105, 83, 79, 60-70, 46, 32 kDas that are apo-HDL, γ-livetin, apo-HDL, γ-livetin, apo-HDL, Phosvitin and apo-HDL, respectively (Amanda *et al*., 2009). A crocodile egg yolk protein band with molecular weight of 47-kDa had molecular weight closely to hen egg yolk phosvithin protein. However, the crocodile egg yolk proteins need to be analyzed with high advanced proteomic methods for more information. The results in this study demonstrate the protein and amino acid identities of Siamese crocodile egg yolk. These may be useful for the egg yolk value adding and functional food application.

Table 2. Amino acid profile of Siamese crocodile egg yolk

Amino acids	Unit (mg/100g)	Amino acids	Unit (mg/100g)
Alanine	2190.19	Lysine	2089.13
Arginine	2349.82	Methionine	823.36
Aspartic acid	3595.95	Phenylalanine	1639.56
Cystine	852.29	Proline	1931.87
Glutamic acid	4665.37	Serine	4062.57
Glycine	1376.26	Threonine	1874.88
Histidine	1016.29	Tryptophan	495.07
Isoleucine	1221.44	Tyrosine	1620.77
Leucine	3247.73	Valine	1486.52

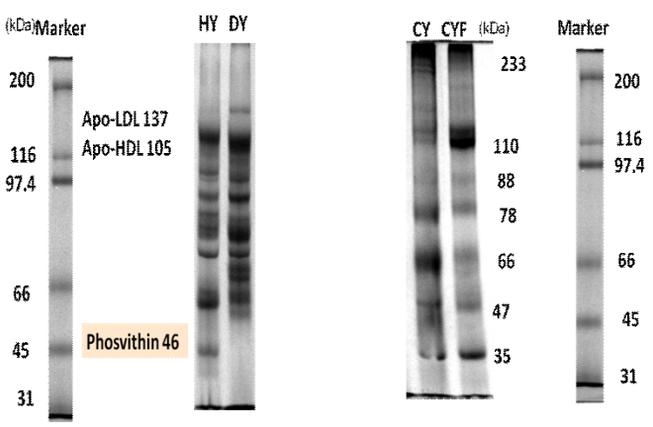

Figure 1. Egg yolk fraction protein patterns of hen yolk (HY), duck yolk (DY), Siamese crocodile yolk (CY) and freeze-dried CY (CYF). kDa: molecular weight in kilodalton ; Marker: Protein standard marker

Acknowledgments

We appreciate Rungtaweechai Crocodile Farm and Wani Thai Limited Partnership for unfertilized Siamese crocodile eggs and technical assistance. P.P. & M.K. were granted fby Department of Zoology. P.P. was supported by grants of Science Achievement Scholarship of Thailand (SAST) and Faculty of Science- Undergraduate Special Problem Matching Fund.

Literature Cited

01. Amada, L., Benjamin, P. and Mario, D. (2009). A method of egg yolk fraction. Characterization of fractions. *Food Hydrocolloids* 24: 434-443
02. Mann, K. and Mann, M. (2008). The chicken egg yolk plasma and granule proteomes. *J. Proteomics* 8: 178-191.
03. Mamara, Mc. and Donald, J. (2003). Nutrition Facts of Options. Eggs Nutrition & Health News.
04. Stadelman, W. J. and Schmieder, H. (2002). Function use of egg. Blackwell, U.S.A.
05. U.S. Department of Agriculture, Agricultural Research Service. (2007). USDA National Nutrition Database for Standard Reference, Release 20. Nutritive Data Laboratory Home page.

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pp 267 - 269

Protein pattern and amino acid profile of Siamese Crocodile (*Crocodylus siamensis*) egg white

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Abstract

Siamese crocodile (*Crocodylus siamensis*) has been considered as an economic animal of Thailand. The mature female lays 20-50 eggs per year which 60% of total eggs are fertilized and 40% are unfertilized eggs. Egg is a good source of proteins and amino acids. However, data of protein in Siamese crocodile eggs has been limited. For guidelines on the usage of unfertilized crocodile egg white in the future, twenty-three crocodile eggs were collected and determined protein pattern and amino acid profile. The results revealed that Glutamic acid was the most abundant in crocodile egg white (6776.76 mg/100g), followed by Aspartic acid (5291.08 mg/100g), Serine (4768.03 mg/100g), Leucine (4602.48 mg/100g) and Lysine (3277.45 mg/100g). The three minor amino acids are Tryptophan (561.87 mg/100g), Methionine (988.52 mg/100g) and Histidine (1386.67 mg/100g). The protein patterns were studied by sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) in the condition that containing mercaptoethanol reducing agent. The concentration of polyacrylamide in the separating gel was 7.5% (w/v). The SDS-PAGE patterns of fresh crocodile egg white were not difference with freeze-dried process, which showed six bands of protein with molecular weight 231.8, 175.4, 135.5, 91.3, 65.1 and 37.2 kDas.

Introduction

The commercial products of crocodile such as skin, meat, internal organs, blood, *etc*. In Thailand, freshwater Siamese crocodile (*Crocodylus siamensis*) is an economic animal. Only 60% of the crocodile eggs ever hatch. The remaining infertile crocodile eggs have not been use. Eggs have well known to be a good source of high-quality proteins, completely has essential amino acids especially in egg white. Due to a lack of research on nutritive value of Siamese crocodile egg, the protein pattern and amino acid profile of the crocodile egg white were studied for its utilization.

Materials and Methods

Egg samples: Captive Siamese crocodile, *Crocodylus siamensis*, 23 unfertilized eggs were collected from Rungtaweechai Crocodile Farm, Don Toom District, Nakhonpathum Province, Thailand. Chicken eggs (n= 3) and duck eggs (n= 3) which purchased from Luang Suwan Vajokkasikij Egg Farm, Kasetsart University and a supermarket (Tesco Lotus Supermarket, Nontaburi branch, Thailand), respectively, were used in protein pattern analysis. All eggs were stored at 4°C in a refrigerator until used.

Egg white preparation: After using hand for eggshell breaking, the egg white part was manually removed by syring into microtubes. The fresh and freeze-dried parts of white fractions were prepared for protein pattern analysis. Moreover, the crocodile egg white was weighted and freeze-dried in a freeze- dryer (Lyomaster, USA). The freeze- dried crocodile egg white was weighted, kept in sterile container and kept at 4°C until chemical composition analysis.

Protein pattern analysis: Homogenization of chicken or hen white (HW), duck white (DW), crocodile white (CW) and freeze-dried CW (CWF) were performed using homogenizer (Omni, USA.) at low speed for 30 seconds. The homogenates were diluted (1:100) with water and aliquot for Sodium Dodecyl Sulfate- polyacrylamide gel electrophoresis (SDS-PAGE) - sample buffer in reducing condition with beta- mercaptoethanol. Protein separation was done by SDS-PAGE (7.5% separating gels and 4% stacking gels at a constant current of 20 mA) with a Compact-PAGE apparatus (Atto, Japan). The gel was stained with Coomassie Brilliant Blue R250 (CBB) and protein pattern was observed via a gel document system (Gel Doc XR System, BioRad., USA). The molecular weight of protein bands was analysed using Quantity One 1-D Analysis Software. (BioRad, USA).

Results and Discussion

In this study, Siamese crocodile eggs had 4.67 cm mean width and 7.94 cm length. The mean weight of crocodile eggs white was 31.69 g. Amino acid profile of the white examined by Gas Chromatography/ HPLC was shown in Table 1. Glutamic acid was the most abundant in crocodile egg white (6776.76 mg/100g), followed by Aspartic acid (5291.08 mg/100g), Serine (4768.03 mg/100g), Leucine (4602.48 mg/100g) and Lysine (3277.45 mg/100g). The three minor amino acids were Tryptophan, Methionine and Histidine, which was 561.87 mg/100g, 988.52 mg/100g and 1386.67 mg/100g, respectively. The quantity of major amino acids in crocodile egg white were lower than hen egg white (FAO, 1970) which comprising of Glutamic acid (10,890 mg/100g), Aspartic acid (6,090 mg/100g), Serine (6,070 mg/100g), Leucine (6,800 mg/100g) and Lysine (4,640 mg/100g). The crocodile egg white was determined for it protein pattern by SDS-PAGE in the separating gel was 7.5% (w/v). The protein patterns of fresh and freeze-dried crocodile egg white were similar, but were different from hen and duck egg white when analyzed by electrophoresis, SDS-PAGE. The crocodile egg white showed 6 bands of protein with different molecular weight with hen and duck white, which have 3 and 2 bands respectively (Figure 1). However, the protein patterns between the fresh- and freeze dried- crocodile egg whites were not difference. The SDS-PAGE protein patterns of crocodile egg white showed 6 bands of protein with molecular weight 231.8, 175.4, 135.5, 91.3, 65.1 and 37.2 kDas. These results suggested the variation of protein between species that probably due to the role of proteins are differ. However, the crocodile egg white proteins need to be analyzed with high advanced proteomic methods for more information. The present study has provide a database of protein in Siamese crocodile egg white which can provide indications as to directions for further research in value adding of the unfertilized crocodile egg.

Table 1. Amino acid profile of Siamese crocodile egg white

Amino acids	Unit (mg/ 100g)	Amino acids	Unit (mg/ 100g)
Alanine	2963.68	Lysine	3277.45
Arginine	1970.87	Methionine	988.52
Aspartic acid	5291.08	Phenylalanine	2177.18
Cystine	2395.50	Proline	2860.67
Glutamic acid	6776.76	Serine	4768.03
Glycine	2282.39	Threonine	2886.39
Histidine	1386.67	Tryptophan	561.87
Isoleucine	1427.61	Tyrosine	1906.35
Leucine	4602.48	Valine	2212.61

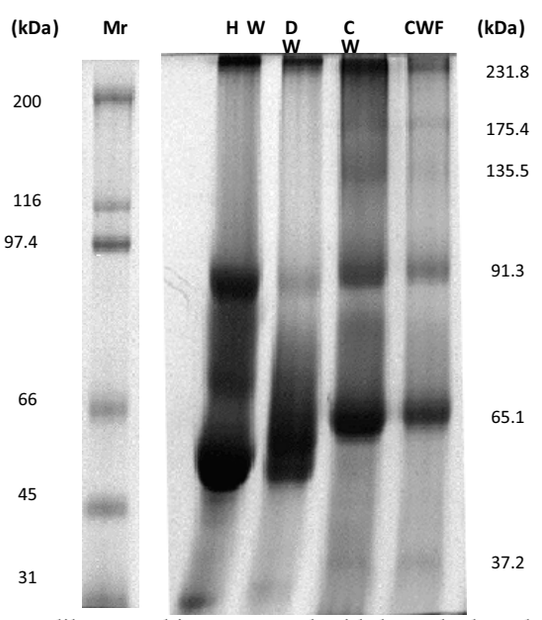

Figure 1. Protein pattern of Siamese crocodile egg white compared with hen, duck and freeze-dried crocodile egg whites. Egg white fraction protein patterns of hen white (HW), duck white(DW), Siamese crocodile white (CW) and Freeze-dried CW (CWF). kDa: molecular weight in kilodalton ; Mr: Protein standard marker

Acknowledgements

We appreciate Rungtaweechai Crocodile Farm and WaniThai Limited Partnership for unfertilized Siamese crocodile eggs and technical assistance. M.K. & P.P. were support by a grant from Department of Zoology. P.P. was granted by Science Achievement Scholarship of Thailand (SAST), and Faculty of Science-Undergraduate Special Problem Matching Fund.

Literature Cited

01. Alleoni, A. C. C. 2006. Albumen Protein and Functional Properties of Gelation and Foaming. *Sci. Agric. (Piracicaba, Braz.)* 63: 291-298. Burley, R.W., Vadehra, D.V. 1989. An outline of the physiology of avian egg formation, pp. 17-23. *In*: The Avian Egg Chemistry and Biology. John Wiley and Sons, New York.

02. Desert, C., Guerin-Dubiard, C., Nau, F., Jan, G., Val, F. and Mallard, J. 2001. Comparison of different electrophoretic separations of hen egg white proteins. *J. Agr. Food Chem.* 49: 45534561.

03. D' Mello, J.P.F. 2003. Amino Acids in Animal Nutrition. 2nd ed. CABI Publishing, London.

04. Food and Agriculture Organization of the United Nations. The Amino Acid Content of Foods and Biological Data on Proteins, Nutritional Study #24. Rome (1970). UNIPUB, Inc., MD. *Egg white amino acid profile*. Available online at http://www.eggnation.co.uk/index.php?route=cms/article&path=1&article_id=9 [16 June 2013].

05. Humblet-Hua, K.N.P., Scheltens, G., Linden, E.V.D. and Sagis, L.M.C. 2011. Encapsulation systems based on ovalbumin filbrils and high methoxyl pectin. *Food Hydrocolloid* 25: 569-576.

06. Huntington, J.A. and Stein, P.E. 2001. Structure and properties of ovalbumin. *J. Chromatogr. B* 756: 189-198.
Li-Chan, E.C.Y.and Kim, H.O. 2008. Structure and chemical composition of eggs, pp. 1-8. *In*: Mine, Y. Eds. Egg Bioscience and Biotechnology. Wiley-Interscience, Hoboken, NJ.

07. Omana, D.A., Wang, J. and Wu, J. 2010. Ovomucin-a glycoprotein with promising potential. *Trends Food Sci. Tech.* 21: 455-463.

Living with crocodiles for sustainable use and management of agro-pastoral dams in Benin: a hope or a scope?

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Nile crocodiles make themselves at home in agro-pastoral dams where they share the dam ecosystem services with local communities. This research aims at assessing how do stakeholders frame the presence of crocodiles, what institutional changes are needed to improve human-crocodile interactions, and how do crocodiles use their habitat. Using a comparative case study design in three villages in Benin, we reflected on an interactional framing perspective to answer to the two first questions. Data were collected from 2009 to 2012 through interviews and Focus Group Discussions. Regarding crocodile habitat use, the three agro-pastoral dam waters were sampled in different seasons and analyzed in the laboratory for the physico-chemical and microbiological parameters. All the spaces visited by crocodiles were featured by observations and interviews. Results showed that the dams were used for multiple purposes. This involved diverse stakeholders with different interests, backgrounds, knowledge, and assumptions. In addition, the dams were the main habitat for crocodiles. The stakeholders involved in the dams framed crocodiles as a main constraint jeopardizing their livelihood because they predated valuable fish species and livestock, destroyed fishing material and the dam infrastructures, and injured mainly children and women. Moreover, the dam water became polluted because the levels of physico-chemical parameters exceed the standards for human and livestock. The dams were also polluted by harmful bacteria (Coliforms, feacal streptocoque, *Escherichia coli,* spore of *Clostridium, Salmonella typhi, Salmonella typhimurium, Salmonella enteritidis,* and *Campylobacter jejuni).* Spaces visited by crocodiles included riparian forest, yam farms and vegetable plots, household heaps, human habitations, schools, and churches. The study suggests that researchers from both social and biological sciences should develop collaborative efforts, use direct observations, measurements and communication tools for evaluating management actions that allow humans living with crocodiles for sustainable management of agro-pastoral dams.

Rituals and symbolism for crocodiles in Goa

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The mugger (*Crocodylus palustris*) is a widely distributed crocodilian species in India. Crocodile worship is a common practice in many parts of India like Dhudhmogra (Mandvi) and Devlimadi (Songadh) in South Gujarat, Vidharba (Maharashtra) and 24 Parganas of West Bengal. A similar practice of worship is also seen in two villages of Ponda Taluka of North Goa district of Goa state for the Mugger (*Crocodylus palustris*).

A small population of the mugger, locally known as 'mange', is confined to a short mangrove-studded stretch of the Kumbarjua- Banastari Canal in South Goa. The Adil Shah of Bijapur introduced crocodiles here, in the 15th Centrury, as deterrents against enemy soldiers. In Goa, one sees an age-old prayer ceremony, of uncertain origin, practiced by the people of Durbhat Wadi village who strongly believe that the animal protects their village.

The legend states that when the village paddy fields were flooded with adjacent sea water, the villagers attempted to pacify the sea by worshiping the crocodiles which were numerous at that time. Every year on the day of the new moon in January, which coincides with the commencement of threshing of harvest paddy, the ceremony of '*Mannge Thapnee' (Clay Crocodile molding)* is performed. The villagers understand that their veneration may not be reciprocated, and so they avoid direct contact with the animal and offer their devotions to a crocodile made from silt. The villagers believe that it is because of their worship that the crocodiles never cause any harm to them or attack their families.

But is this enough? The sightings of the animal have reduced in the past 1year with a few cases of conflict reported recently, and the habitat also seems to be facing the pressures of urbanization and industrialization.

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pp 271 - 277

Bio-logging science: a mechanistic approach to understanding Gharial *Gavialis gangeticus* (Gmelin, 1789) ecology

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Abstract

The study was conducted in Hastinapur Wildlife Sanctuary, Uttar Pradesh between October - November 2009. We attached data loggers with a newly developed time-scheduled release system to 2 captive-reared Gharial. Multi sensor data logger and the digital still-picture logger were deployed to record swim speed, diving behavior, ambient temperature, stroke frequency, body angle and the surrounding environment. While, the acceleration data logger was deployed to record diving behavior, ambient temperature and head movements that may relate to prey capture. The system released the loggers from the Gharial 24 hr after deployment, and allowed us to retrieve the loggers via VHF radio signals. The results obtained though at nascent stages elucidate the underwater behaviour and fine-scale movements of Gharial in the wild. Further modifications in the experiment [Technological and the use of large sample size] can contribute towards better understanding, consequently helping in the improved conservation management of the species.

Key words: Data-logger, Acceleration, Dive, Gharial, Conservation.

Introduction

Bio-logging can be defined as 'the use of miniaturized animal-attached tags for logging and/or relaying data about an animal's movements, behaviour, physiology, and/or environment' (Rutz & Hays 2009). Bio-logging technology allows researchers to take measurements from free-ranging animals as they move undisturbed through their environment (Bograd *et al.* 2010). The approach is suggested to have emerged in the 1940s when a capillary depth gauge was attached by Pers Scholander onto a harpooned whale to gather information about the cetacean's maximum diving depth (Naito 2004) hence, bio-logging science could thus be >60 year old. Kooyman (1965) first used the data-logging technique by developing a time depth recorder (TDR) to study the diving physiology of Weddell Seals *Leptonychotes weddellii*. Length of the data was limited to one hour, but this was the first device used to obtain detailed information on underwater activity of a marine animal. By 1975 improvements in the TDR made possible the recording of the diving activity of Fur Seals *Callorhinus Ursinus* and Weddell Seals *Leptonychotes weddellii* over 14 days (Kooyman *et al*. 1976) and later in 1981 for > 3 months. With the emergence of microprocessors that made possible miniaturization and the logging of several additional variables with the incorporation of appropriate sensors, the range of application extended considerably to various marine animal species (e.g. Wilson & Bain 1984, Naito *et al*. 1989, Watanabe *et al*. 2008 and Sato *et al*. 2009). Research on reptiles has largely focused on Sea Turtle. For e.g. Migratory patterns and feeding grounds of post-nesting female Hawksbill Turtle *Eretmochelys imbricate*tagged on the Yucatan Peninsula, Mexico have been described by Cuevas *et al.* (2008). McClellan & Read (2009) have demonstrated the use of sonic and satellite telemetry to determine the vulnerability of juvenile Green Turtle *Chelonia mydas* to incidental capture in an artisanal gill net fishery off the coast of North Carolina, USA.

Figure 1. **Gharial *Gavialis gangeticus* Critically Endangered Crocodilian.**

The Gharial *Gavialis gangeticus* is an endemic, river dwelling crocodilian of the North Indian subcontinent, whose wild populations have been depleted throughout much of its former range (Ross & Magnusson 1990 and Chowfin & Leslie 2013). The total breeding population of the species in the world is now estimated to be less than 200 individuals making it a critically endangered

species (IUCN 2007). The species is listed as Schedule I under the Indian Wildlife (Protection) Act, 1972. Gharial are both taxonomically and structurally unique; being the only living representative of a once well-represented family and that having the most attenuated snout of all crocodilians. It is interesting to note that name Gharial is derived from *ghara*, an Indian word for *pot* because of a bulbous knob (*narial excrescence*) present at the end of their snout. The *ghara* also renders Gharial the only visibly sexually dimorphic crocodilian. Present day conservation threats mainly include habitat destruction, depletion in prey bio-mass and retaliatory killings by fishermen who consider Gharial as competitors for the same resource *i.e* fish.

Study area

Kukrail Gharial Breeding Centre, Lucknow (Uttar Pradesh)

Kukrail reserved forest, which covers an area of 2000 ha is located 12 km away from the State Capital i.e Lucknow (Fig. 2a). It was established as the Gharial Breeding Centre in 1976 in order to rear and release the captive Gharial into the wild to revive the depleting population of the species (Singh *et al*. 1999). These captive reared Gharial are released into Rivers Chambal, Ganga and its perennial tributaries i.e Sharda, Ghagra, Girwa and Ramganga. The Centre also runs the captive breeding programme on turtles.

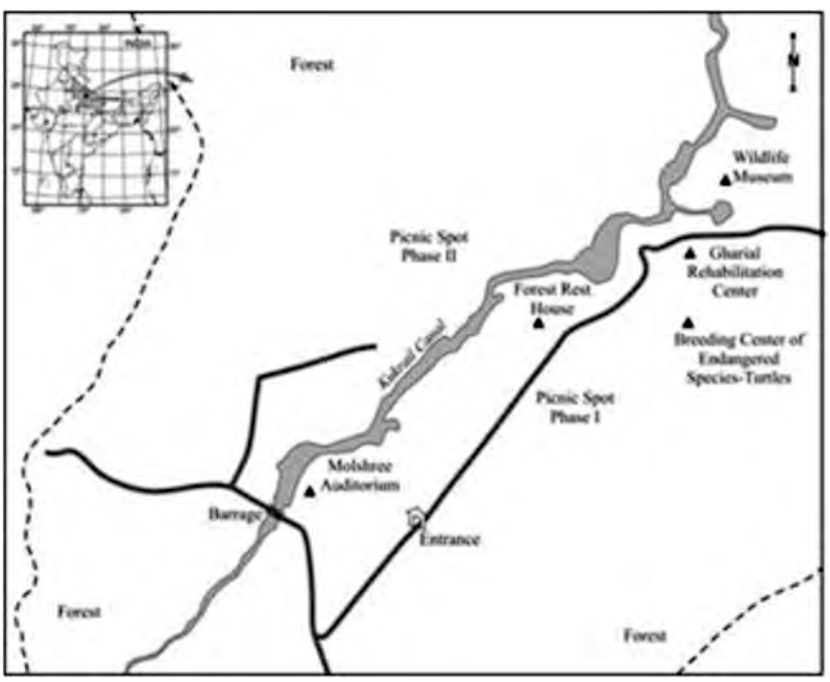


Figure 2a. **Kukrail Gharial Breeding Centre, Lucknow (Uttar Pradesh)**

Hastinapur Wildlife Sanctuary, Meerut (Uttar Pradesh)

Hastinapur Wildlife Sanctuary (28°46′ and 29°35′N Latitude and 77°43′ and 78°30′E Longitude), which was established in 1986 in the Indo-Gangetic plains (Fig. 2b). The Sanctuary encompasses an area of 2073 km^2 representing about 0.2% of the total geographical area of the Gangetic grasslands. The area of the Sanctuary mainly falls under five districts of Uttar Pradesh namely Muzzaffarnagar, Bijnor, Meerut, Ghaziabad and Jyotibafuley Nagar (Noida). Altitude of the area ranges between 130 and 150m above sea level. Three distinct seasons are recorded; winter from October to mid March, followed by summer from mid March to mid June and monsoon starts in mid June and continues till September. May and June are the hottest months when the temperature reaches about 45°C; December and January are coldest and the temperature can fall near to 0°C. The annual precipitation is about 1200mm. The vegetation of the Sanctuary can be classified into three main types - tall wet grasslands in low-lying areas that remain inundated for most parts of the year; the short wet grasslands remain dry from mid winter to the onset of the monsoon, and the dry scrub grasslands on raised grounds amidst the Ganga and on highland, also known as 'Khola' (Nawab 2000). A diverse fauna exists in the Sanctuary which makes this area a biodiversity hotspot in the Gangetic plains.

Methodology

The study was conducted between 26 October 2009 and 30 November 2009 in two phases. In Phase I the study was conducted at the Kukrail Gharial Breeding Centre in captive conditions and in Phase II the observations were made under wild conditions.

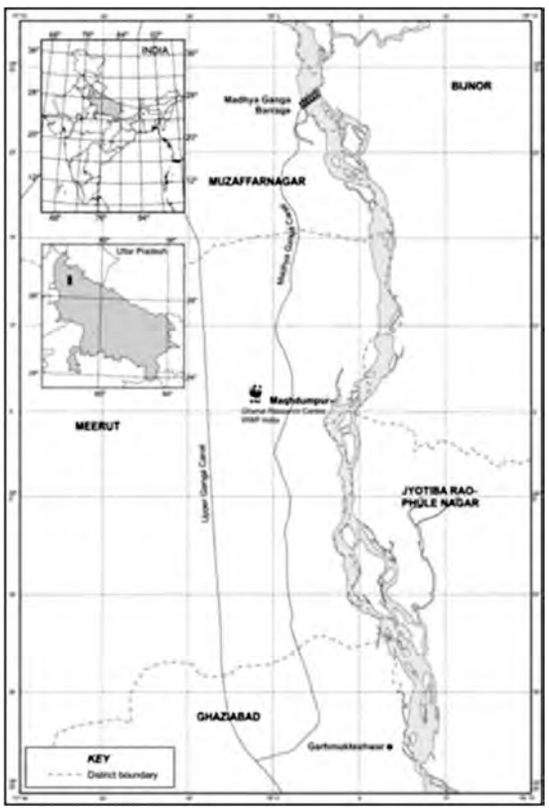


Figure 2b. **Hastinapur Wildlife Sanctuary, Meerut (Uttar Pradesh)**.

Instruments used

(i.) A multi sensor data logger (W190L-PD3GT) (Fig. 3). This weighs 92 g in the air and is 22 mm in diameter and 124 mm in length. It records swim speed (1 sec), depth (1 sec), 3-axes accelerations (32 Hz) and temperature (1 sec).

(ii.) An acceleration data logger (W190L-D2GT) (Fig. 4). This weighs 18 g in the air and is 15 mm in diameter and 50 mm in length. It records depth (1 sec), 2-axes accelerations (32 Hz) and temperature (1 sec).

(iii.) A digital still-picture logger (DSL190-VDTII). This weighs 73 g in the air and is 22 mm in diameter and 138 mm in length. It records 1M pixel picture every 5 seconds.

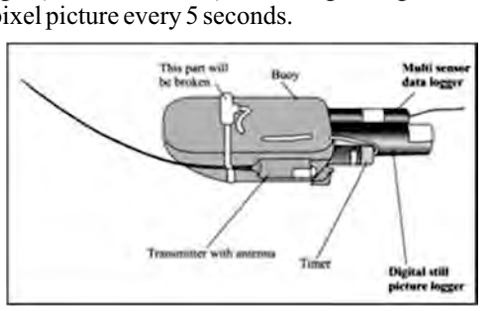


Figure 3. Multi Sensor Data Logger and Digital Still-Picture Logger with a buoy (281g in the air).

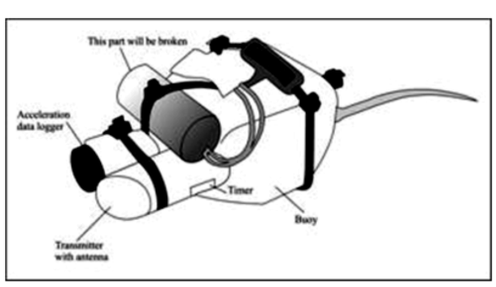


Figure 4. Acceleration Data Logger with a buoy (71g in the air).

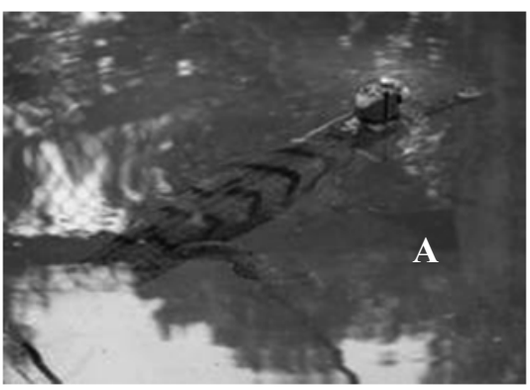
Deployment of bio-loggers

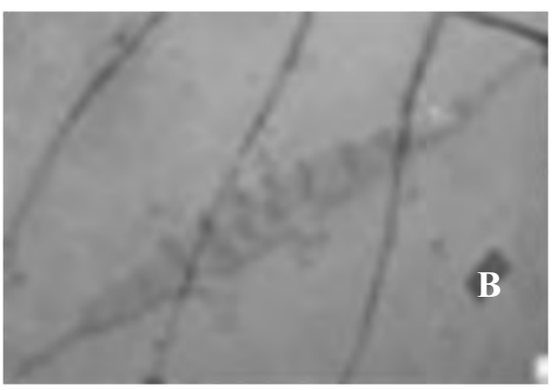
Captive Gharial were used to establish the method of deployment of bio-loggers. The multi sensor data logger and the digital still-picture logger were fixed with a buoy "larger device" (281g in the air) and deployed on the back at the junction of double crest whorl and single crest whorl of the sub-adult animal to record swim speed, diving behavior, ambient temperature, stroke frequency, body angle and surrounding environment. The cable tie was passed through the holes grilled into the scutum (dead cells) and the device was fixed. The acceleration data logger with a buoy "smaller device" (71 g in the air) were deployed on the head at the depression of the skull notch of the juvenile animal to record diving behavior, ambient temperature and head movements that may relate to prey capture. Both the devices were composed of the data loggers, buoy, VHF transmitter, timer and cables. Epoxy glue did not work for the skin of the Gharial. Silicone glue seemed to be effective at first glance, however, part of the plastic mesh got unstuck. The unstuck part was then fixed using cyanoacrylate glue "Loctite". The mixture of the silicone glue and cyanoacrylate glue worked well for attaching the mesh on captive animals.

Monitoring and Observations

Time series data of movements: Under experimental conditions at Gharial Breeding Center at Kukrail, Lucknow; Uttar Pradesh

Acceleration Data Logger with a buoy (71g in the air) was deployed on the juvenile male Gharial [A] (Body mass = 6.4 kg; Total body length = 133 cm) and the Multi Sensor Data Logger and Digital Still-Picture Logger with a buoy (281g in the air) was deployed on the sub-adult male Gharial [B] (Body mass = 12.5 kg; Total body length = 162 cm). The animals were in good health condition.4 hr timers were used to detach the devices from the animals during the experimental study at Kukrail. The instrumented animals were released into the experimental ponds and their underwater behavior was observed. When the timers got activated in the water, it made a 'low' sound. The animals resting at the bottom of the pond reacted to the sound and swam, however, no abnormal behavior was observed.





According to the acceleration data, juvenile Gharial rested for most of the time at the bottom of the experimental pond (Fig. 5a). Fluctuation with large amplitude in acceleration was recorded prior to the detachment of the device, the juvenile Gharial might have been disturbed with the surrounding noise but showed no abnormal behaviour (Fig. 5b). The timer was activated at 14:39 hr and the device got detached from the animal.

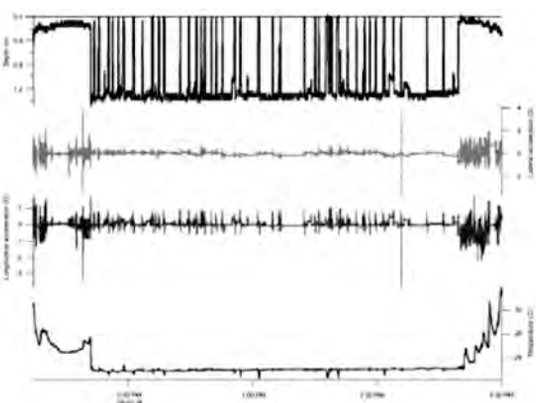


Figure 5a.

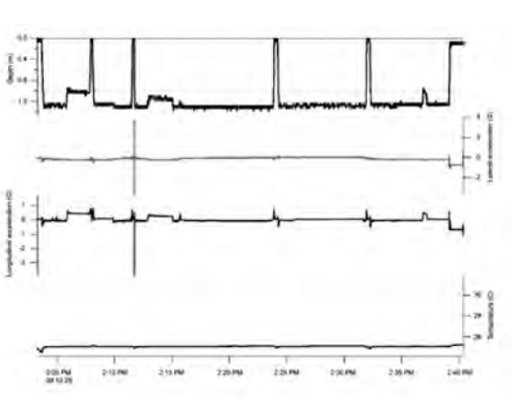


Figure 5b.

Sub-adult Gharial repeated resting dives and shallow water swimming. The propeller of the logger did not rotate well, which indicates that the swimming speed was lower than the stall speed of propeller (0.2 0.3 m/s) (Fig. 6a). When the timer got activated and the device got detached at 20:16, the animal reacted to the low sound and swam for 30 sec and then stopped and rested at the bottom of the pond showing no abnormal behaviour (Fig. 6b).

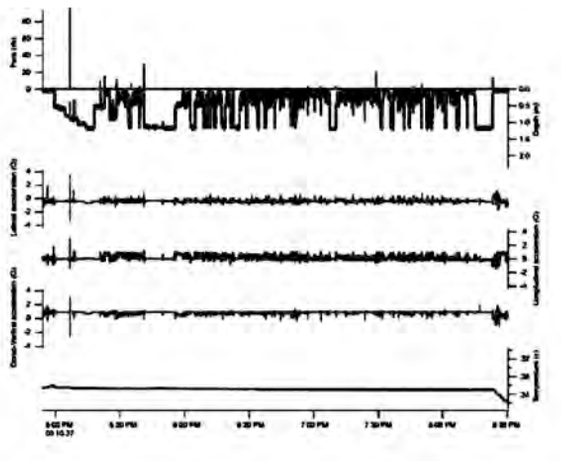


Figure 6a

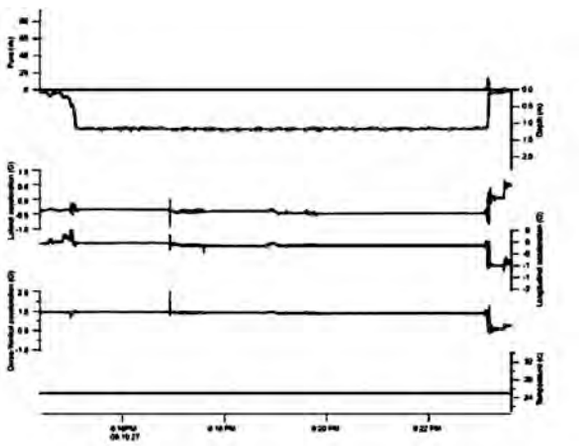


Figure 6b

Time series data of movements: Under wild conditions at Hastinapur Wildlife Sanctuary (Meerut) Uttar Pradesh

Juvenile male (Body mass = 6.4 kg; Total body length = 133 cm) and Sub-adult male (Body mass = 12.5 kg; Total body length = 162 cm) were released into the wild (River Ganga) at Hastinapur Wildlife Sanctuary. The methodology established for the deployment of the bio-loggers under captive conditions was used. The system released the loggers from the Gharial 24 hr after deployment, and allowed us to retrieve the loggers via VHF radio signals. The instrumented animals were released at 12:17 hr and at 12:55 hr respectively on 30 October, 2009.

Juvenile Gharial recorded repeated dives and the deepest dive depth was 1.4 m. Increase in ambient temperature was gradual; however it decreased abruptly, this indicates that the animal sometimes came out to bask on the land (Fig. 7a). Lateral and longitudinal accelerations indicate activity of the animal during dives, when the animal was at the surface, activity was higher in comparison when the animal was diving (Fig. 7b).

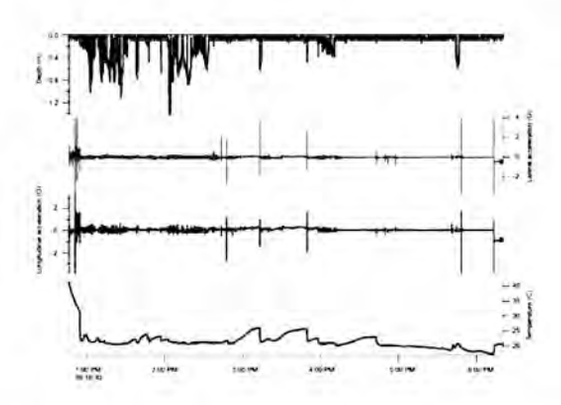


Figure 7a.

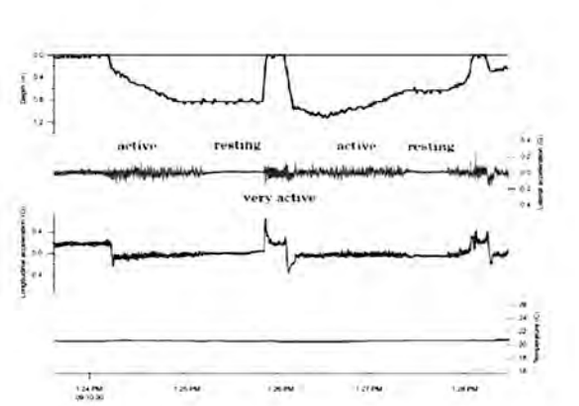


Figure 7b.

Sub-adult Gharial recorded repeated dives and the deepest dive depth was 4.7 m. Ambient temperature recorded to increase gradually, but it decreased suddenly which ndicates that the animal occasionally came out for basking. The propeller did not rotate well during the period of deployment, this could be because; the swim speed of the animal might have been lower than the stall speed of the propeller (0.2-0.3 m/s) or the suspension in the river water might have affected the stall speed (Fig. 8a). The animal was inactive in some dives. Dive durations of the inactive dives were usually long, longest dive duration recorded was 40 minutes (Fig. 8b). Stroking movement in the deepest dive (4.7 m) was different from those in the typical dives. It stroked in the descending position only, this suggests that the animal had positive buoyancy during the deepest dive and ascended using the positive buoyancy. There is a possibility that the Gharial might change the inhaled air volume in relation to the dive depth.

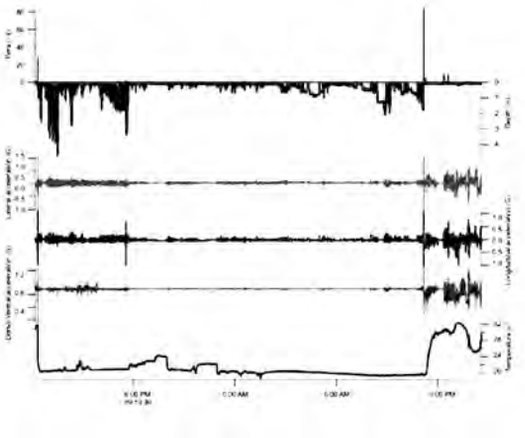


Figure 8a.

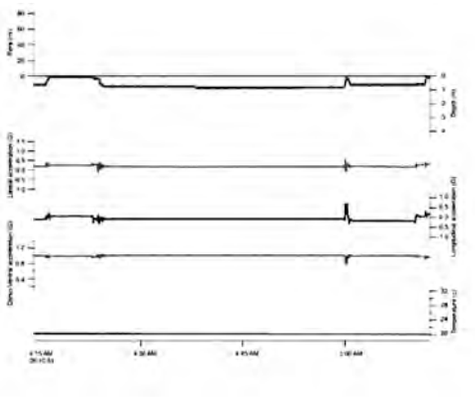
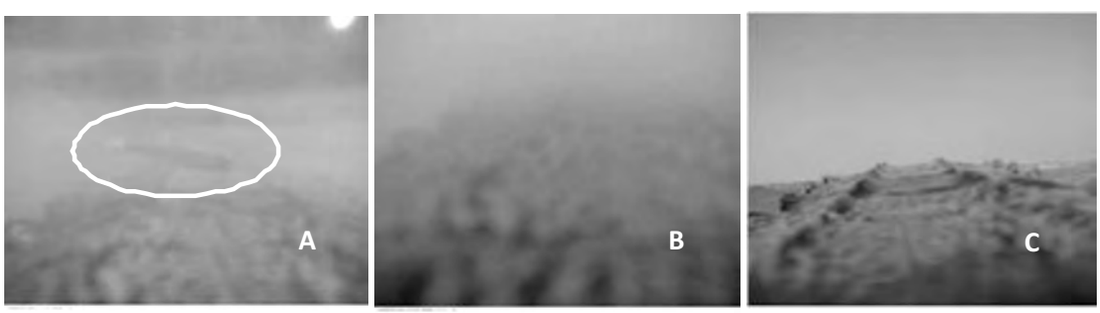


Figure 8b.

Still picture

The camera was deployed on the sub-adult Gharial released in the river and 14507 pictures were recorded (1 M pixel every 5 sec.). Fish was recognized in some pictures [A], most pictures were not clear [B] and when the animal came out for basking the picture recorded were clearer [C].



Understanding Gharial behaviour and way forward

The results elucidate that Gharial may have capacity of long dive. The sub-adult Gharial dove for more than 40 min (this is concluded from the 24 hr data collected). Time series data can also describe how often Gharial haul-out on the land. Present study indicates that Gharial can swim in darkness when they dive deeper than 1 m in Ganga River. This raises a question of how the animal captures its prey underwater or do they always feed on the surface waters?

In the present model (PD3GT, 22 mm in diameter), it was difficult to measure swim speed by the propeller as its diameter was small. 3MPD3GT logger is available and can be tried, the diameter of the logger is 28 mm and the stall speed is also better than the present model used.

Results indicate that camera does not work well under water in River Ganga. Although pictures were possible at the surface and on land but the recording period was prolonged. The present model can be modified with a depth sensor that can activate the functioning of the depth trigger for taking pictures.

The need is for larger data sets and on experiments on more number of individuals, this shall contribute towards better understanding of the underwater behaviour of Gharial under natural condition, consequently helping in the improved conservation management of the species.

Acknowledgements

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Literature cited

01. Block, B.A. 2005. Physiological ecology in the 21st century: Advancements in bio-logging science. *Integr Comp Biol.* 45: 305320.

02. Bograd1, S. J., Block, B. A., Costa, D. P. and Godley, B. J. 2010. Biologging technologies: new tools for conservation. Introduction. *Endang Species Res.* 10: 17.

03. Burger, A.E. and Shaffer, S.A. 2008. Application of tracking and data-logging technology in research and conservation of seabirds. *Auk.* 125:253264.

04. Chowfin, S.M and A. J. Leslie. 2013. A preliminary investigation into nesting and nest predation of the critically endangered, gharial (*Gavialis gangeticus*) at Boksar in Corbett Tiger Reserve, Uttarakhand, India. *Int. J. Biodiv. and Consn*. Vol. 5. No. 2. 54-57.

05. Cooke, S.J., Hinch, S.G., Wikelski, M., Andrews, R.D., Wolcott, T.G, Butler, P.J. 2004. Biotelemetry: a mechanistic approach to ecology. *Trends Ecol. Evol.* 19:334343.

06. Cuevas E, Abreu-Grobois FA, Guzmán-Hernández V, Liceaga-Correa MA, van Dam RP (2008) Post-nesting migratory movements of hawksbill turtles *Eretmochelys imbricata* in waters adjacent to the Yucatan Peninsula, Mexico. *Endang Species Res.* 10:123133.

07. IUCN. 2007. IUCN Red List of Threatened Species. [Online] Available at: http://www.iucn.org/themes/ssc/redlist2007/docs/05_gharial_en_low.pdf.

08. Kooyman, G.L. 1965. Techniques used in measuring diving capacities of Weddell seals. *Polar Rec.* 12: 391394.

09. Kooyman, G.L., Gentry, R.L. and Urquhart, D.L. 1976. Northern fur seal diving behavior: A new approach to its study. Science. 193: 411412.

10. McClellan CM, Read AJ (2009) Confronting the gauntlet: understanding incidental capture of green turtles through fine-scale movement studies. Endang Species Res 10: 165-179.

11. Naito, Y., Le Boeuf, B.J., Asaga, T. and Huntley, A.C. 1989. Long-term records of an adult female northern elephant seal. Nankyoku Shiryô (*Antarct. Rec*.). 33: 19.

12. Naito, Y. 2004. New steps in bio-logging science. *Mem. Natl Inst. Polar Res*. (Spec. Issue). 58: 5057.

13. Nawab, A. 2000. Plant species composition and structure of Hastinapur Wildlife Sanctuary, U.P. India. M.Sc. Dissertation, Aligarh Muslim University, Aligarh, (India).

14. Ropert-Coudert, Y and Wilson, R.P. 2005. Trends and perspectives in animal-attached remote sensing. *Front. Ecol. Environ.* 3: 437444. Ross, C.A and Magnusson, W.E. 1990. Living Crocodilians. *In*: Crocodiles and Alligators, (Ed C.A. Ross). Merehurst Press, London. pp 58-75.

15. Rutz, C. and Hays, G. C. 2009. New frontiers in biologging science. *Biol. Lett.* 5:289292.

16. Sato, K., Shiomi, K., Watanabe, Y., Watanuki, Y., Takahashi, A and Paul, J. 2009. Scaling of swim speed and stroke frequency in geometrically similar penguins: they swim optimally to minimize cost of transport. *Proc. R. Soc. B.* 1515.

17. Singh, A., Singh, R. L. and Basu D. 1999. Conservation Status of the Gharial in Uttar Pradesh. Pp. 91-94. *In*: Indian Crocodile Conservation Project; ENVIS (Wildlife & Protected Areas); Vol. 2, No 1; Wildlife Institute of India, Dehradun.

18. Watanabe, Y., Wei, Q., Yang, D., Chen, X., Du, H., Yang, J., Sato, K., Naito, Y and Miyazaki, N. 2008. Swimming behavior in relation to buoyancy in an open swim bladder fish, the Chinese sturgeon. *J. Zool.* 275: 381-390.

19. Wilson, R.P. and Bain, C.A. 1984. An inexpensive depth gauge for penguins. *J. Wildl. Manage.* 48: 10771084.

Embryogenesis of crocodilian skin

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Crocodilian skin functions primarily as a mechanical, osmotic and thermal protective device. This study examined the chronological development of skin in embryonic through to hatchling, Estuarine (*Crocodylus porosus*) and Australian freshwater (*Crocodylus johnstoni*) crocodiles. Eggs of each species were incubated under appropriate conditions then sampled over time until hatching. Following histological processing skin was examined using light and electron microscopy. In the first trimester a simple squamous then columnar epithelium surmounts a quickly differentiating dermis consisting primarily of irregular collagen bundles. Early in the second trimester scale formation became evident above a loose dermal layer surmounting a thicker dense dermis. Melanocytes were evident in the epidermis and melanophores in the dermis. In the final trimester the epidermis increased in its cellular complexity with tough β keratin over the presumptive scales and soft α keratin in interscalar areas. The underlying loose dermis remained relatively static in its development but the dense dermis increased in its thickness dramatically. At hatching melanophores were common in the flank and back dermis of both species. Birefringent chromatophores were present in the flank and back dermis of *C. porosus* but not *C. johnstoni*. Chromatophores were absent from the belly skin of both species. Polynomial relationships for total; epidermal, dermal and skin thickness were developed to describe incubation development. All were linear except for total epidermal thickness in *C. porosus* where initial slow development to day 21 was followed by a 10 fold increase to day 27 then slow growth to day 41 and again rapid growth until hatching. This study provides an insight into possible times for the manipulation of incubation to improve skin quality in crocodilians

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Crocodiles in Sri Lanka threat and protection?

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Introduction

Sri Lanka is home of two crocodilian species: the mugger or marsh crocodile, *Crocodylus palustris* and the estuarine or saltwater crocodile, *Crocodylus porosus*. The Sri Lankan populations of both species are threatened, although there are numerus national parks and crocodiles have been specifically protected there since 1938 through the Fauna and Flora Protection Ordinance.

Clearly the management of crocodile populations in the wild and the protection of their habitat on Sri Lanka is not a success story. Publications from hundreds of years ago reported crocodiles on the island and such descriptions from the 17th and 18th centuries, and even into the19th century, indicate that crocodiles must have been quite numerous in some regions (Whitaker & Whitaker 1979).

The wild population status of *C. palustris* has changed dramatically in recent years, and the status of *C. porosus* is nothing short of catastrophic. A little more than 30 years ago, Whitaker & Whitaker (1979) estimated the total population of *C. palustris* on Sri Lanka at about 2,800 specimens (not including specimens of one year or younger). Two decades later, Santiapillai & De Silva (2001) and Das & De Silva (2005) estimated only 1,220 specimens left, or about 43 percent of the population that existed in the 1970s.

Even more critical is the situation with *C. porosus*. In the 1970s, Whitaker & Whitaker (1979) estimated the population along the southwestern coast of Sri Lanka at 250 specimens (not including specimens of one year or younger), and around the rest of the entire island only 125 more, for a total population of 375 saltwater crocodiles. This figure corrected the previous estimate made by Whitaker & Daniel (1978) of 500-750 specimens, reducing the number practically by half. According to Santiapillai & De Silva (2001) and Das & De Silva (2005) the current population of *C. porosus* on Sri Lanka is possibly no more than 300 specimens. During a recent study De Silva (2010) reported the observation of only 50 saltwater crocodiles ranging in length from 60 cm to 4.5 m

The decline in numbers of crocodiles has several causes. With *C. porosus* the main causes are hunting for meat and skins, destruction of nesting grounds, and urbanisation of coastlines. Construction of new roads contributes by giving humans access to once remote areas. Various recent studies (e.g. Porej 2004, Gramentz 2008a, 2008b) have indicated a definite negative correlation between crocodile numbers and the intensity of human activities, such as fishing and construction.

Distribution on Sri Lanka

There is hardly any precise information available about the past distribution and abundance of *C. porosus* on Sri Lanka. However, the presence of the species in the southwestern part of the island was mentioned by Kelaart (1852). He wrote that the species was commonly found in the large rivers of the island, including the Mutwal River near Colombo, and also it occurred in Southern Province.
Whitaker & Whitaker (1979) reported the presence of saltwater crocodiles in western Sri Lanka and along the southern coast in the rivers Bentota Ganga, Maha Oya, Kelani Ganga they determined that the principle remaining population of the species was restricted to this section of coast. Other previously large populations (Pottuvil, Batticola, Trincomalee and Mullaitivu) had already disappeared by the time of their investigation. This species has also completely disappeared from Jaffna Peninsula (Santiapillai & De Silva 2001). Other localities cited by Deraniyagala (1930) Chilaw, Puttalam, Colombo, Panadura, Bolgoda, Kalutara, Bentota, Gintota, Wakwella, Matara, Hathagala near Tongalla, and Trincomalee are all also along the western and southwestern coasts.

Whitaker (2004b) suggested that a reproducing population of *C. porosus* might still exist only in the swampy region of Muthurajawela, mentioned by Devapriya (2004) and Porej (2004). Gramentz (20081, 2008b) reports occasional successful nesting in the Bentota Ganga; De Silva (2008, 2010), from the Nilwala Ganga in the south. Recently crocodiles were confirmed on Mannar Island in nortwestern Sri Lanka, but the species to which it belonged could not be determined (Somaweera et al. 2004).

Santiapillai & De Silva (2001) believe that relatively abundant and secure populations of both crocodile species are currently found only in the two protected areas of Ruhuna National Park in the southeast and Wilpattu National Park in the northwest. They confirmed the presence of *C. palustris* at 105 of 113 studied localities; *C. porosus*, at only 33 both species were found at 25 localities in the parks. A very large mugger crocodile population lives in the already mentioned Ruhuna National Park, where De Silva (2010) observed 493 specimens.

Threat factors

Unfortunately it seems that because the crocodiles are protected in the nationalparks (which is unquestionably necessary), little or no importance is given to preserving crocodile habitat elsewhere on the island. In the past, the natural habitat of *C. palustris* was altered by the construction of water reservoirs and thousands of kilometers of artificial irrigation canals. This gave the crocodiles unnatural alternatives, and the ability to travel from one reservoir to another for this reason *C. palustris* is more widely distributed than *C. porosus*. Juvenile and subadult mugger crocodiles may also travel overland to colonise neighbouring areas of habitat. Saltwater crocodiles are much more dependent on the sea, and therefore much less likely to travel from one body of water to another.

Porej (2004) estimated the number of saltwater crocodiles in the Muthurajawela marshland to be 15 specimens. With increasing human activities and draining of wetlands, this area of crocodile habitat is steadily shrinking (Devapria 2004). Presumably very few large saltwater crocodiles are left on Sri Lanka, making the discovery of a 5.03 m specimen a couple of years ago all the more exciting. Captured on 24 February 2009 at Hendala, about 20 km north of Colombo, this large crocodile was taken to the protected Udawalawe National Park. In the past, crocodiles of this size were not uncommon. Older literature (see Deraniyagala 1939) mentions saltwater crocodiles on Sri Lanka measuring 5.25 and 6.6 m in length. Even in the national parks, crocodiles of this size are no longer found. The largest saltwater crocodile seen by Santiapillai et al. (2000) in Ruhuna National Park was only about 3 m long; the largest mugger crocodile, about 2.5 m. One recent large *C. porosus* of 4.5 m in length was reported by De Silva (2010).

Another indication of the serious threat to crocodiles on Sri Lanka is the current population structure. According to Cott (1961) and Graham (1968), a normal crocodile population should consist of mostly adults, with relatively small numbers of juveniles. The percentage of sighted adults accounted only for 7% when recent hatchlings are included and 11% without hatchlings. Both recent hatchlings and yearlings represented 40% of the sighted crocodiles. The other two immature size categories as well as adults were represented in 7% of the sightings (Fig. 1). Alltogether 93% of the counted crocodiles were immatures and only 7% were adults. According to Cott (1961) and Graham (1968) in an environment unaffected by human influences a normal crocodile population should be dominated by adults and juveniles should be represented in comparatively low numbers. However, the population in the area of the Bentota Ganga is strongly skewed towards hatchlings and yearlings. In Arnhem Land, Northern Australia, Messel (1977) reported that hatchlings accounted for 23.22% of *C. porosus* seen and 23.06% were one year old. Similar findings were published by Porej (2004) for the Muthurajawela marsh region, where juveniles and subadults made up 78% of the saltwater crocodiles sighted.

I do not believe that the distribution presented in figure 2 reflects the actual proportion of crocodiles in the different size classes. Instead I suppose that all but hatchlings and yearlings are biased from the behaviour of the crocodiles. Frankly, it seems possible that crocodiles from the age of about one year onwards develop a high degree of wariness. Probably because of the above mentioned causes.

Messel (1977), Webb (1977a) and Webb et al. (1977) reported an average egg number of 50.3 (range 40-62, n = 18 nests) in *C. porosus* nests. Therefore it is possible that even with relatively high mortality during incubation and shortly after hatch all hatchlings sighted and reported here came from just one and probably not more than two nests. This is also supported by the small number of reproducing adults and of what is known of the behaviour of the hatchlings. Webb (1977b) reported a strong site fidelity in *C. porosus* hatchlings for the first time period after hatch. After two months the majority of hatchlings (69%) were still within 0.5 km of the nest. However, Deraniyagala (1937) reported that in each of two nests from Maha Bellana (Western Province) only 25 eggs were found.

Due to the land use behind the mangroves with some little villages and residents, paddy fields and tracks following the course of the river it seems very unlikely that a nest would have remained unnoticed (especially when it would be guarded by a female). I rather assume, also because of the scattering pattern shown in figure 3, that the hatchlings are from one nest laid on an island. According to Webb (1977a) hatchling groups stay together for up to $2^{1}/_{2}$ months after hatching.

In the next size category (30-50 cm SVL, 1-2 years) considerably more downstream movement was found by Webb (1977b) and therefore the yearlings in figure 4 show a greater dispersion. However, the number of nests (season 2007) must have been also very few (possibly also only one or two).

The small number of sighted adult saltwater crocodiles is most probably due to their decimation. Another factor is undoubtedly that the adults have survived and grown large are those animals that have learned to be alert to intruders and

remain mostly unseen. Senanayake (1995) reported that crocodiles on Sri Lanka are killed because of fear of attacks on humans and domestic animals. Also Santiapillai et al. (2000) and Santiapillae & Wijeyamohan (2004) emphasize the bad reputation that crocodiles have on Sri Lanka. Even 30 years ago, Whitaker & Whitaker (1977) saw that public education was needed. Also De Silva (2010) addressed the necessity of education of the people living and fishing in the Nilwala Ganga in Matara of the precautions they should take to prevent crocodile attacks and also why crocodiles and their habitats should be conserved. Nonetheless, today there is still not a single special protection program for crocodiles.

Porej (2004) reported that in the Muthurajawela marsh and Negombo lagoon region, mother saltwater crocodiles guarding their nests are still killed. When a nest is discovered by fishermen, they keep returning to the site until they find the mother and kill her. If the eggs are freshly laid when the nest is found, they are collected to be eaten. If the eggs are further developed, the nest is burned.
Devapriya (2004) mentions that in addition to collecting eggs, fishermen also kill crocodiles for meat and skins. This is partly associated with superstition some believe that eating crocodile meat will help cure asthma. Inquiries carried out by De Silva (2010) and its team revealed that some people have placed a piece of crocodile skin on the sole of the shoe as it helps to improve eyesight. The fat is also supposed to have medicinal properties, and crocodile meat is believed to be an aphrodisiac (Simon 1954).

Some methods by which saltwater crocodiles are captured have hardly changed since being described by Deraniyagala (1939). A hen or a dog or puppy is tied to a tree at the water's edge. Flapping wings, yelping, or splashing attracts the attention of nearby crocodiles. When a crocodile takes the bait and begins to roll, men throw spears at it, aiming for the weakly armored underside.

When fishermen in the Muthurajawela and Negombo region inadvertently catch juvenile crocodiles along with fish, they eat them just the same (Porej 2004). Devapriya (2004) reports that juvenile crocodiles can get caught in fish traps and drown. Nest destruction and the killing of juvenile and subadult crocodiles that get caught in fishing nests (where they sometimes drown) is also seen on the Nilwala Ganga (De Silva 2008). One fisherman told De Silva (2010) that he had killed five juvenile crocodiles that had been caught in his nets, and other fishermen had similar stories. For example, De Silva (2010) reported that on 30th January 2010 a crocodile which was caught in a fish net at Karawgaha tank was killed and eaten. Furthermore he reported that of twelve fishermen interviewed all except one killed the crocodiles which were trapped in fishing nets. One adult mugger of approximately 2 m length had severely beaten by the fishermen to take it from the net. The injured crocodile was left on the banks of the tank, but fortunately it was subsequently rescued and released after its recovery into another tank (De Silva 2010).

Also railway tracks are a threat to crocodiles when they lead through their habitat (fig. 9). De Silva (2010) reported a case of a large (ca. 4 m, 13 foot) saltwater crocodile which died on the spot after being hit by the train that was heading for Chilaw from Colombo.

Whitaker & Whitaker (1977, 1979) affirmed that if the saltwater crocodile is to survive on Sri Lanka, it would need a protected area where it could live without conflict with humans. Groombridge (1982) wrote that in addition to commercial hunting, mainly during the 1950s and 1960s habitat loss is the main threat to saltwater crocodiles. While De Silva (2010) pointed that the is “a good recovery and appreciable population of crocodiles (mugger) especially in some wildlife parks”, the “crocodiles outside national parks face many threats as they often get killed due to various human activities including the human crocodile conflict”.

Indeed there is currently not a single protected area for *C. porosus* in the most crucial southern part of Sri Lanka. Steel (1989) explains that protection measures for saltwater crocodiles are quite unpopular with local residents, who commonly consider the animals dangerous monsters. Officially, crocodiles have been protected in Sri Lanka for decades (see De Silva 2008). According to Whitaker (2004a), however, protection for *C. porosus* in India and on Sri Lanka exists only on paper; he considers it unlikely that the species will survive there.

Today, all of the coastlines and river mouths in the southwestern part of the island Moratuwa, Panadura, Kalutara, Bentota, Balapitiya, Ambalangoda, and near Galle are virtually free of saltwater crocodiles. Whether significant populations exist farther upriver or in inland lakes is not known. The discovery of yearlings, subadults and adults of the saltwater crocodile inhabiting the Nilwala Ganga in Matara was reported by De Silva (2010), which is an indication for a breeding population. The few remaining suitable areas of habitat are also in danger of being lost to urbanisation. A compounding factor is the threat caused by industrial and organic waste in the rivers. Devapriya (2004) concludes that these materials are harmful to the health of the crocodiles.

Saltwater crocodiles on the Bentota Ganga

The case of the Bentota Ganga will now be looked at more closely to illustrate the situation. The data presented here are partly based on a preliminary survey carried out from 23 to 26 November 2007 (day counts at these two days) (Gramentz

2008a) and a more comprehensive one carried out from 24 September to 9 October 2008 (four day and four night counts from 29 September until 9 October). The third night count had to be stopped after about 60 min due to engine problems. It was tried to time the counts with the dark phases of the lunar cycle as well as falling tides (what was only partly possible at the end of the survey). On each survey large areas of the Bentota Ganga were searched, one day time survey included the Kaluwamodera Ganga and in two day time surveys the Welipenne Ganga. Total search time was 37 hrs 55 min (23 hrs 5 min during the day, 14 hrs 50 min during the night).

All night counts could only be carried out up to a maximum turning point for safety reasons as groups of illegal alcohol (Arrack) producers were active along the river. So unfortunately night counts from upper parts of the Bentota Ganga are still lacking.

It was hoped to find some concentrations of recent hatchlings to limit the area which is still used and suitable for nests. According to Deraniyagala (1939) the peak of the nesting season along the coast of Sri Lanka is July and August and the hatchlings of this report are those very recently hatched.

Although it is a common practise not to include hatchlings in calculations of relative abundance because of their high rate of natural mortality they were included here in some calculations for comparison to other non-hatchling size classes.

Sizes of the crocodiles were estimated at closest range. Only three recent hatchlings were measured and released after a few minutes at precisely the same spot. Crocodiles up to 35 cm total length were treated as recent hatchlings and specimens up to 70 cm as yearlings. Other immature size classes were 0.70 1.50 m and 1.50 2.30 m (fig. 5). Crocodiles were counted as adults when their size was estimated from 2.30 m onwards (fig. 6). According to Webb & Manolis (1989) females reach maturity usually at a total length of 2.30 m. Therefore all crocodiles from that size onwards were considered being adults. 'Eyes only' (fig. 7) counts were treated as non-hatchlings (yearlings appr. >- 70 cm total length onwards). The crocodiles were counted from an outboard-powered boat with 15 hp engine at a cruising speed of about 3.1 to 3.6 miles/hour. During night counts the open water and the river banks were scanned by two persons with powerful torches. Once a crocodile was sighted its position was recorded using a GPS Garmin Geko 201 and approached so much so that it was possible to estimate its size. Size estimates as total length were made by two observers. In those instances (during night counts) where size estimates could not be made because the crocodiles were well hidden within mangroves and could not approached closer by boat were classed as 'eyes only' (EO).

Multiple 'eyes only' counts at the same location during different night surveys are assumed to represent the same specimens. Therefore, the 25 EO counts most probably represent a maximum of 15 individuals (fig. 7). Furthermore due to the habitat structure in which 'eyes only' counts occurred all were probably from immature crocodiles.

The numbers of crocodiles have been corrected when it was assumed that there were double or multiple counts of the same specimen. This was the case when a crocodile of the same size was located at the same spot or when after comparison of photos the spotting pattern on at least one flank/body side was found to be identical.

The Bentota Ganga has a length of about 55 km and its tributaries are predominantly the Welipenne Ganga, Pitugal Ganga, Pelawatta Ganga, Elpithiya Ela and Migaspithiya Ela. Beside these rivers the Kaluwamodera Ganga enters the Bentota Ganga close to its mouth. The Bentota Ganga and its tributaries are situated almost completely in the lowland wet zone of southwestern Sri Lanka. The original bank area of the river is dominated by mangroves.
Of a number of crocodiles belonging to different size classes their association to the bank structure was noted (counts represent sightings and not individuals). As can be seen in figure 10 A most hatchling sightings were found in close association with mangrove habitats. This association is slightly reduced in yearlings (fig. 10 B), but this type of bank structure is clearly of major importance in these size classes. As a side note one hatchling which was caught among mangroves was still busy swallowing a large shrimp. The presence of hatchlings during day and night in the water amongst mangroves and sometimes perched on small branches was previously documented and reported by Webb (1977a). So some aspects of hatchling behaviour at Sri Lanka were the same as at Arnhem Land, Northern Australia.

Deraniyagala (1930) described the saltwater crocodile from Bentota as a “man-eater”, but also notedthat the species had become rare on Sri Lanka. In 1955 he described the invalid *Crocodylus porosus minikanna* the subspecies name means man-eater in Sinhalese. *Crocodylus porosus* is considered by a number of authors as the largest recent crocodile species (e.g. Deraniyagala 1936, Daniel 1983, Groombridge 1987, Steel 1989), whereas the latter author and previously Bellairs (1969) discussed data of specimens with exaggerated lengths. On the average adults have a total length of 3.50 4.50 m (Brazaites 1974). Undisputedly there is a possible danger for humans by adult *C. porosus* (Pooley & Ross 1989, Neil 1971).

The number of crocodiles in Bentota Ganga has definitely been continually dropping for several decades. This may be due to their negative impact on the development of infrastructure and tourism, which are welcomed by the authorities. Until the 1970s, crocodiles were still relatively abundant at the river mouth where shorelines that have since been built up

still had the same thick mangrove vegetation that is found in other river areas. The survival of saltwater crocodiles is strongly linked to the preservation of mangrove shore regions (Bustard & Choudhuri 1980). Today, saltwater crocodiles have completely disappeared from the immediate area of the river mouth due in part to past hunting, alteration of the shoreline, and current use for tourism, including a variety of recreational water sports (figs. 11 and 12) (Gramentz 2008a, 2008b).

The same is true of other regions along the southwestern coast of Sri Lanka. I was told that crocodiles have not been sighted in the Indian Ocean off the mouth of the Bentota Ganga "for ages". Deraniyagala (1930) wrote that during the two years before his publication several of these crocodiles measuring 2-3 m were caught off the western coast at Kalutara, Panadura, and Moratuwa.

Most saltwater crocodile habitat consists of rivers affected by ocean tides, and colonised from the seas. The network of roads and human habitation in southwestern Sri Lanka makes it virtually impossible for these crocodiles to travel overland to find new waterways. It makes no difference how good conditions might be farther up the rivers. If the lower regions of the rivers are uninhabitable for crocodiles, their migration is severely restricted if not impossible. According to Deraniyagala (1936), saltwater crocodiles do not inhabit any inland waters on Sri Lanka. Due to hunting and destruction of nesting sites, populations in upriver retreats are becoming fragmented, with isolated subpopualtion consisting of ever-diminishing numbers of individuals.

Larger saltwater crocodiles measuring 1.5 m and more are still hunted and eaten in the catchment areas of the Bentota Ganga and the Welipenne Ganga. This is also reflected in the small numbers of sightings of crocodiles of this size. Since hunters know that killing crocodiles is against the law, the meat is sold secretly.

Crocodilians are still greatly feared in the Bentota Ganga. In the past there were a greater number of large specimens in the river, and there were more victims of attacks among the local residents. One example is the "Bentota Man-eater", a crocodile that ate two people before it was killed. This may or may not be the same crocodile that was known as "White Face", reported by Van De Bona (1996) and Karunathila Ka (1991). According to Deraniyagala (1939), the "Bentota Man-eater" had a total length of 2.5 m. According to Van De Bona (1996) the crocodile known as "White Face" lived in the tributary Welipenne Ganga, near Kuruduwatta, and had a total length of about 4.5 m.

In any case it is possible that in the past there were many large saltwater crocodiles in the Bentota Ganga that noticable scars on their heads, perhaps from missed attempts to kill them with clubs or spears whenever such a specimen was sighted, it may have been called "White Face". Van De Bona (1996) wrote that especially fishermen tried to kill crocodiles in the Bentota Ganga whenever they could secretly, since doing so was against the law. Eventually a "White Face" was shot and killed.

It is noteworthy that despite these stories, the responsible local authorities haver never issued information to advise local residents on how to live in harmony with crocodiles in the river, nor have they posted any kind of warnings or fences to protect people and domestic animals form possible attacks. At least partly this negligence may have caused casualties which in turn may seem to justify i to kill the larger and more dangerous crocodiles.

The time when very large crocodiles were living in Sri Lanka is long gone. Possibly the largest saltwater crocodile ever killed in Sri Lanka was a specimen caught in Matara, which was about 6.70 m (over 22 feet) long (Clark 1971). In late October 2010 a local newspaper reported that a large saltwater crocodile (measuring either 4.2 or 4.8 m, depending on the source) had been killed in Mawilangathurai Lagoon by villagers from Kanthankudi (Batticaloa District) in eastern Sri Lanka for revenge, because it had supposedly eaten a fisherman.

It is difficult to say at what point and to what degree crocodiles are disturbed by human activities. In Bentota Ganga, near the towns of Aluthgama and Bentota, people are out on the water practically all day long. Tourists enjoy daytime water sports such as windsurfing, jet skiing, waterskiing, canoeing, speed boating, tour boating, and so on, until just before sunset. Shortly thereafter, the local fishermen begin their evening and nighttime fishing.

Large areas of the Bentota Ganga are used for extracting sand. On 4th October 2008 I counted a total of 39 boats out for this purpose just between 11:30 a.m. and 12:45 p.m., between 06°21'59.5" north latitude 80°07'49.1" east longitude and 06°23'41.5" north latitude 80°05'48.8" east longitude. During the same time, no crocodiles were sighted in this stretch of water. Although the habitat there seemed to be of suitable quality, the crocodiles had either moved away to other areas, or were keeping especially well hidden because of the disturbance.

During my first investigation on the Bentota Ganga in 2007, I twice saw a saltwater crocodile (presumably the same on both times) (fig. 8) of more than 2.5 m in length, in the shade under mangrove branches (Gramentz 2008a). The following year I was able to account for three saltwater crocodiles of just over 2.3 m (Gramentz 2008b). De Silva (2008) and his team also counted only three large specimens in the Nilwala Ganga these were possibly all longer than 3 m in length, and one possibly as much as 4.5 m long. According to Messel (1977), a great approach distance (to which a person can come

before the animal will flee) is an indication of the intensity of hunting in the past. Where crocodiles were hunted, or are still hunted, the animals demonstrate an increased sense of alertness and caution with a longer approach distance. Two specimens (fig. 6) with estimated lengths of 2.4 m and 2.6 m allowed our boat to aproach to 50-60 m in the open water before diving (Gramentz 2008b). They surfaced after a couple of minutes, having moved farther away from the boat. Crocodiles of at least about 2 m in length with access to shoreline vegetation allowed approach to distances of only 4-5 m.

Since there are still some nests being produced, it can be supposed that there are more adult crocodiles in the Bentota Ganga than were sighted, although numbers are low. Bayliss et al. (1986) remarked that there are crocodiles, especially large ones, that are never seen. It may also be quite difficult to see even young crocodiles in areas where hunting pressure is great. Bustard (1986) reported that young *C. porosus* quickly lern to avoid approaching boats.

There is also a possibility that light pollution or photopollution (excessive or obtrusive artificial light) may have a negative effect on saltwater crocodile orientation. Brock (1960a) repeatedly observed crocodiles moving toward lights at night. Especially crocodiles in the lower reaches of the Kaluwamodera Ganga are subject to significant amounts of artificial light from houses, bridge illumination, boats, and even occasional fireworks. Lamps located directly along the shoreline that are kept on for the most part of the night could have a considerable impact on the behaviour of the crocodiles.

Natural predators

In addition to anthropogenic threats a natural threat for nests and hatchlings is possibly *Varanus salvator* which occurs in large densities in the area (Deraniyagala 1936, Daniel 1983, Gramentz 2008b) Whitaker & Whitaker 1978) consider water monitors a potential predator of *C. porosus* nests at North Andaman. Wilson (1971) observed a monitor digging out a crocodile nest at Sri Lanka. Also De Silva (2010) listed *V. salvator* as a predator of the eggs and he also mentioned mongoose (*Herpestes* sp.), wild boar (*Sus scrofa*), and golden jackel (*Canis aureus*) as predators of crocodile nests. The destruction of nests and feeding on hatchlings by *V. salvator* and other predators in already threatend crocodile populations has an even more significance.

Causes for conflicts between crocodiles and humans

Some crocodiles may abandon their sense of caution when potential food is at stake. On the Bentota Ganga, I observed observed a 1.9 m specimen on 30th September 2008 (20:42 hours) and on 6th October 2008 (19:25 hours) probably the same animal, even though the sightings were about 2.5 km apart (both on the same side of the river). In both cases meat scraps had been dumped near the water's edge in one place it was beef and goat meat left as part of a Muslim school's Ramadan festivities; in the other place, fish and chicken scraps from a weekly market. Both installations were strongly illuminated for a number of hours after sunset. It is possible that this individual is making a connection with the light and a possible food source.

One resident of a village along the Nilwala Ganga explained that in the past conflicts with crocodiles used to be quite seldom. However, since riverbanks are recently being fortified and built up, with money from tsunami relief funds, there are more crocodiles coming near the village, and conflicts have consequently increased. The structure of the banks has been changed to decrease the effects of tides on water level, and increase the amount of water available for crop irrigation (e.g. for rice paddies). Crocodiles are attracted to these areas that now have consistently higher water levels. At first the villagers were happy with the improved irrigation, but with time, as more crocodiles began to move in, their initial euphoria turned to distress. Of course the residents do not want to relinquish the new abundance of water, but they do want to get rid of the crocodiles whatever it takes.

Part of the blame for the bad reputation of crocodiles among the general public is sensationalist media reporting. One of my assistants remembered how a local newspaper had reported a bus accident 17 or 22 years ago. Full of passengers, the bus had gone off a bridge into the Kaluwamodera Ganga (a tributary of the Bentota Ganga). According to the report, the saltwater crocodiles living in the river had viciously attacked the people in the water. A friend of my assistant's, who lives directly on the river near the bridge, saw the accident. He said that there were indeed crocodiles in the water, but the dead and injured people were all victims of the accident, not crocodile attacks. But newspaper sell better with fantastic stories of crocodile attacks.

The Island (www.island .lk), a Sri Lankan online newspaper, reports nearly ten people killed by crocodiles every year in the Nilwala Ganga. However, this number is certainly an exaggeration. De Silva (2008) recorded a total of only eight deaths by crocodiles for almost an entire decade (1998-2007). Sensationalist, false reporting by local media naturally contributes to the persistence of the bad reputation of crocodiles in the public few.

De Silva (2010) found that of 131 investigated cases of human crocodile conflicts 37% of the people as reaction killed the offending crocodiles themselves. Sometimes family members and friends of the victim killed the crocodiles and in one incidence the father and friends have killed up to 4 crocodiles in revenge.

Recommendations and considerations

The recommendations listed below refer not only the main stream of the Bentota Ganga but to all waterways in the study area as side creeks and tributaries as for example the Welipenne Ganga.

1. At no time or place should nets be stretched from one side of a river across to the other side (fig. 14). Crocodiles that are inadvertantly caught in any fishing activities should be set free, not injured or killed.

2. Police boats should patrol the waters at irregular intervals throughout the day and night to curb illegal hunting.

3. Sand collecting (fig. 15) should not be allowed in areas inhabited by crocodiles.

4. Sand mining in the proximity of burrows of muggers should be stopped as it causes disturbance of the crocodiles. Whenever tanks have to be renovated or cleared this has to be done very carefully that no burrows are affected or even destroyed in the course of the process.

5. As disturbance is beside killing and habitat destruction a threat for the crocodiles as it keeps them away from a former inhabited area water sports such as jet skiing, waterskiing, banana boating, windsurfing, and speed boating should be completely prohibited. This would also be for the safety of tourists. Human casualties due to carelessness would turn the mind of the public against the crocodiles. An exhaustive report on measurements for the prevention of crocodile attacks was recently published by De Silva (2010).

6. At certain locations, especially where there is easy access to the water, signs should be posted, in Sinhalese (fig. 16) and English, warning of crocodiles and prohibiting swimming, The signs should help the people to perceive crocodiles as a normal part of life in these areas. Possibly not more than ten signs should be needed in the Bentota Ganga region.

7. Clearing of trees for firewood, and consequent destruction of crocodile nests, must be stopped in the Nilwala Ganga region (De Silva 2008).

8. Hotels and guesthouses should provide information brochures explaining the habits of saltwater crocodiles in the Bentota Ganga, and the importance of protecting them.

9. No more permits should be issued for new buildings or for adding on to existing buildings in the shore regions of the Bentota Ganga and Nilwala Ganga, for example. Illegal buildings should be torn down at the cost of the builder, and the shore should be be restored, as much as possible, to its riginal natural condition. To avoid further habitat destruction and reduce the potential for conflict between humans and crocodiles, boat traffic, and other disturbances, no more building should be allowed along the still largely intact shore regions of rivers and lakes.

10. All buildings and small villages near the banks of the rivers (including the Bentota Ganga) should be protected with fences on the side facing the water.

11. In all buildings close to the banks of the rivers the lamps should be screened.

12. Fireworks should be completely prohibited near rivers the noise probably disturbs the communication between crocodiles. On New Year's Eve Brock (1960b) noted a modification of the behaviour of his *C. niloticus* which was usually silent. After each bang of the fireworks the crocodile responded with one short and loud roar).

13. On railroad tracks leading through regions inhabited by crocodiles a speed limit should be maintained which is slow enough to stop the train to avoid accidents with crocodiles crossing or resting on the track.

14. The discarding of animal scraps from market, etc. into the rivers should be stopped.

15. Inland and off-shore fishermen must be emphatically informed that crocodiles are protected animals and should never be killed if they are caught inadvertantly. Should the crocodiles because of their size impose a threat to the fishermen the release should to be done by specialists. The safety of both humans and crocodiles has priority over material damages. A fund could be raised for compensation of damaged fishing gear for local people.

16. "Problem crocodiles" should not be simply shot they should be relocated.

17. There is a long time history of fishing in the Bentota Ganga. A number of human casualties resulted in the construction of the boats used for fishing. Therefore safer boats should be employed to reduce or at best prevent crocodile related human deaths and injuries. Many of the boats currently in use are narrow canoes with outriggers for support (locally named catamarans), the main body being shallow and completely open. A deeper, broader, and more enclosed boat type would be safer for transport and fishing.

18. Many shorelines in the remaining distribution of *C. porosus* in wester, southwestern and southern Sri Lanka are under enormous pressure from urbanisation. A complete suspension of construction in these areas is urgently necessary. A building-free strip of at least 40 m wide must be maintained along crocodile inhabited waters, with no access roadways to the shoreline. De Silva (2008) points out that a 20metre strip along shorelines is technically public land, and destruction of the mangroves there could easily by protected by law.

19. Porej (2004) states that mortality of eggs and juveniles must be reduced as a primary measure for the protection of the population of saltwater crocodiles in the Muthurajawela marshes.

If disturbance factors in the lower section of the Bentota Ganga are actually prevented in the framework of future conservation measures a problem could appear from natural movements by certain age classes. Webb (1977b) noted that rivers could lose crocodiles from the mouth particularly those in and above the two to three year old category. In fact in this study a specimen which was sighted closest to this area was approximately 1.90 m in total length (fig. 12). The distance from that sighting to the mouth of the Bentota Ganga is about 2.3 km. It is therefore possible that in this already depleted population at least some specimens from the Bentota Ganga leave the river for the Indian Ocean. On the other hand the mouth of the Kaluwamodera Ganga lies opposite the mouth of the Bentota Ganga into the ocean and the crocodiles also have the chance to enter this river.

The creation of a protected region for *C. porosus* in southwestern Sri Lanka is urgently necessary, and in my opinion this should at least encompass the Bentota Ganga and Madu Ganga as well as their tributaries. Any further land clearing or development for urbanisation, agriculture, or tourism in this area must be prevented.

Henle & Streit (1990) showed that nearly all reptile species, which became extinct due to influence of man within the last 2000 years were inhabiting islands. Due to habitat destruction and disturbances in the lower sections of rivers, the local population of *C. porosus* is more an "inland-species" with the same risk to become endangered. The trend of a diminishing population size which has been documented over the last decades clearly is directed towards a local extinction if not large scale protection measures are immediately initiated. Destruction of nests during clearing of vegetation in crocodile habitats was reported by De Silva (2010).

Future outlook and little reason for optimism

The status of both species of crocodiles on Sri Lanka is very bad. Already in 1971 the editor of the Sri Lankan journal Loris (vol. 12 (3):152) noted: "Crocodilians are threathened with extinction all over the world. In Ceylon this is true at least of the Estuarine crocodile (*Crocodylus porosus*)." And in fact saltwater crocodiles are actually on the brink of extinction in the Bentota Ganga and other rivers of southwestern and southern Sri Lanka the larger specimens, which were decimated by hunting in past years, are especially affected.

References

01. Bayliss, P., G.J.W. Webb, P.J. Whitehead, K. Dempsey & A. Smith (1986): Estimating the abundance of saltwater crocodiles Schneider, in tidal wetlands of the Northern Territory: a mark-recapture experiment to correct spotlight counts to absolute numbers, and the calibration of helicopter and spotlight counts. Aust. Wildl. Res., **13**: 309-320.
02. Bellairs, A. (1969): The Life of Reptiles. Volume I. London (Weidenfeld and Nicolson), 1-282.
03. Brazaitis, P. (1974): The identification of living crocodilians. Zoologica, **58** (3-4): 59-101.
04. Brock, J. (1960a): Panzerechsen im Zimmer. Aquar.- und Terrarienzeitschr. (DATZ), **13** (1): 18-23.
05. Brock, J. (1960b): Panzerechsen im Zimmer VII. Aquar.- und Terrarienzeitschr. (DATZ), **13**: 212-216.
06. Bustard, H.R. (1971): Crocodiles in Australia. In: Crocodiles. Proceedings of the First Working Meeting of Crocodile Specialists. New York 15 17 March 1971. IUCN Publications New Series, Supplementary Paper No 32: 34-40.
07. Bustard, H.R. (1974): Rapid learning in wild crocodiles (*Crocodylus porosus*). Herpetologica, **24** (2): 173-175.
08. Bustard, H.R. & B.C. Choudhuri (1980): Conservation furure of the saltwater crocodile (*Crocodylus porosus* Schneider) in India. J. Bombay Nat. Hist. Soc., **77** (2): 201-214.
09. Clark, A. (1971): Sport in the Low-country of Ceylon. Dehiwala (Tisara Prakasakayo). First edition 1901. Chapter 14, Crocodiles: 64-68.
10. Cott, H.B. (1961): Scientific results of an inquiry into the ecology and economic status of the Nile crocodile (*Crocodylus niloticus*) in Uganda and Northern Rhodesia. Transactions Zoological Society London, 29: 211-356.
11. Das, I. & A. De Silva (2005): A Photographic Guide to Snakes and other Reptiles of Sri Lanka. London (New Holland Publishers), 144 pp.
Daniel, J.C. (1983): The Book of Indian Reptiles. Bombay (Oxford University Press), 141 pp.
12. Deraniyagala, P.E.P. (1930): The crocodiles of Ceylon. Spolia Zeylanica, **16** (1): 89-95.
13. Deraniyagala, P.E.P. (1936): Reproduction of the estuarine crocodile of Ceylon. Ceylon J. Sci., Sect. B., Spolia Zeylanica, **19** (3): 253-277.
14. Deraniyagala, P.E.P. (1937): The nest-guarding habit of the estuarine crocodile of Ceylon. Ceylon Journal of Science, **20** (2): 253-254.
15. Deraniyagala, P.E.P. (1939): The Tetrapod Reptiles of Ceylon. Vol. I. Testudinates and Crocodilians. Colombo Museum Natural History Series. Ceylon Journal of Science, 412 pp.
16. Deraniyagala, P.E.P. (1955): A new race of estuarine crocodile from Ceylon. Spolia Zeylanica, **27** (2): 277-279.

17. De Silva, A. (2008): The status of the saltwater crocodile (*Crocodylus porosus*) inhabiting the Nilwala River, Matara District, and its impact on the community. Unpublished Report.
18. De Silva, A. (2010): Crocodiles of Sri Lanka: Preliminary Assessment of their Status and the Human Crocodile Conflict Situation. Mohamed Bin Zayed Species Conservation Fund (project number 0905271). Unpublished report, 49 pp.
19. Devaprija, W.S. (2004): A survey of the saltwater crocodile (*Crocodylus porosus*) in the Muthurajawela urban marsh. Lyriocephalus Special Issue, **5** (1 & 2): 25-26.
20. Graham, A. (1968): The Lake Rudolph crocodile (*Crocodylus niloticus laurenti*) population. Report to the Kenya Game Department by Wildlife Services Ltd.
21. Gramentz, D. (2008a): Zur Abundanz, räumlichen Verteilung und Bedrohung von *Crocodylus porosus* im Bentota Ganga, Sri Lanka. elaphe, **16** (3): 41-52.
22. Gramentz, D. (2008b): Einige Bemerkungen zur Ökologie und zum Verhalten von *Varanus salvator* (Laurenti, 1768) im Südwesten von Sri Lanka. Sauria, **30** (3): 13-20.
23. Groombridge, B. (1982): The IUCN Amphibia-Reptilia Red Data Book. Part 1. Testudines, Crocodylia, Rhynchocephalia. Gland (The Gresham Press), 426 pp.
24. Groombridge, B. (1987): The distribution and status of world crocodilians. Wildlife Management Crocodiles and Alligators. Chipping Norton, NSW, Australia: 9-21.
25. Henle, K. & B. Streit (1990): Kritische Betrachtungen zum Artenrückgang bei Amphibien und Reptilien und zu dessen Ursachen. Natur und Landschaft, **65** (7/8): 347-361.
26. Karunathila Ka, N.T. (1991): (in Sinhalese), Bemgagabada witthi (Story of the Boundary of the River). Colombo (Godage and Brothers), 202 pp.
27. Keelart, E.F. (1852): Prodromus Faunae Zeylanicae; Contributions to the Zoology of Ceylon. Colombo (John Hieler), 197 pp., append. 62 pp.
28. Messel, H. (1977): The crocodile programme in Northern Australia. Population surveys and numbers. In: Australian Animals and their Environment (H. Messel & S.T. Butler, Sydney (Shaekespeare Head Press): 207-236.
29. Neill, W.T. (1971): The Last of the Ruling Reptiles. New York (Columbia University Press), 486 pp.
Pooley, A.C. (Tony) & C.A. Ross (1989): Sterblichkeit und natürliche Feinde. In: Krokodile und Alligatoren (ed. C.A. Ross), Hamburg (Jahr-Verlag): 92-101.
30. Porej, D. (2004): A case study of the saltwater crocodile *Crocodylus porosus* in Muthurajawela Marsh, Sri Lanka: consideration for conservation. J. Bombay Nat. Hist. Soc., **101** (3): 337-343.
31. Santiapillai, C. & S. Wijeyamohan (2004): New sightings of crocodiles from northern Sri Lanka. Crocodile Specialist Group Newsletter, **23** (1): 13-14.
32. Senanayake, N. (1995): Human and reptile conflicts: impact on reptiles in Sri Lanka. Lyriocephalus, **2** (1 & 2): 86.
33. Simon, G.H. (1954): Ceylonese beliefs about animals. Western Folklore, **13** (4): 260-267.
34. Steel, R. (1989): Crocodiles. Bromley (Christopher Helm), 198 pp.
35. Van de Bona, T.A. (1996): (in Sinhalese), Bemthota ruhunu doratuwa (Bemthota the Gateway to Ruhana). Colombo (ANCL Lake House), 164 pp.
36. Webb, G.J. (1977a): Habitat and Nesting. - In: Australian Animals and their Environment (H. Messel & S.T. Butler), Sydney (Shaekespeare Head Press):239-284.
37. Webb, G.J. (1977b): Growth, movement, river distributions and general comments. In: Australian Animals and their Environment (H. Messel & S.T. Butler), Sydney (Shaekespeare Head Press):285-312.
38. Webb, G.J. & C. Manolis (1989): Crocodiles of Australia. Sydney (Reed Books), 160 pp.
39. Webb, G.J., H. Messel & W. Magnusson (1977): The nesting of *Crocodylus porosus* in Arnhem Land, northern Australia. Copeia, **1977** (2): 238-249.
40. Webb, G.J. & H. Messel (1979): Wariness in Crocodylus porosus (Reptilia: Crocodilidae). Aust. Wildl. Res., **6**: 227-234.
41. Whitaker, R. (2004a): Regional report from CSG vice chairman for South Asia, Romulus Whitaker. Crocodile Specialist Group Newsletter, **23** (1): 8-9.
42. Whitaker, R. (2004b): Salties or muggers? Crocodile Specialist Group Newsletter, **23** (1): 12-13.
43. Whitaker, R. & Z. Whitaker (1977): Sri Lanka crocodile survey. Loris, Colombo, **14** (4): 239-241.
44. Whitaker, R. & Z. Whitaker (1978): A preliminary survey of the Saltwater Crocodile (*Crocodylus porosus*) in the Andaman Islands. J. Bombay Nat. Hist Soc., **75** (1): 43-49.
45. Whitaker, R. & Z. Whitaker (1979): Preliminary crocodile survey Sri Lanka. J. Bombay Nat. Hist. Soc., **76** (1): 66-85.
46. Wilson, C. (1971): Crocodile! Loris, **12** (3): 151-152.

Fig. 1: Relationship of sightings of immature and adult *Crocodylus porosus* (survey 2008).
A including recent hatchlings, B without recent hatchlings.

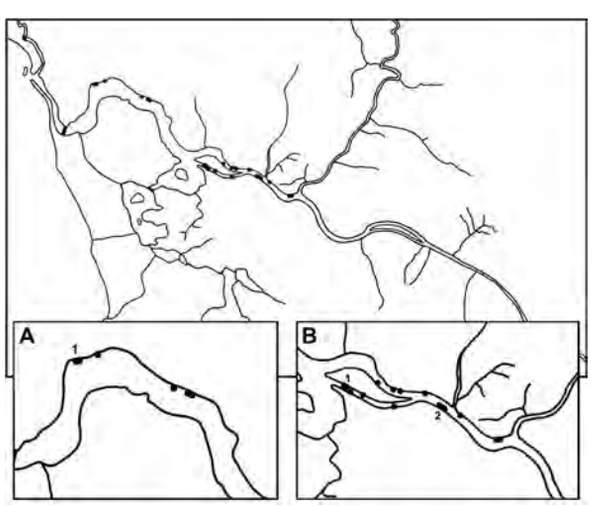


Fig. 2: Population structure according to sightings of *Crocodylus porosus* in the Bentota Ganga and Welipenne Ganga (survey 2008).

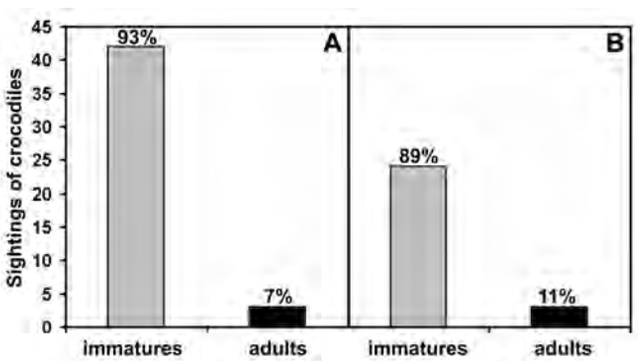


Fig. 3: Distribution of sighted recent hatchlings of *Crocodylus porosus* (survey 2008).

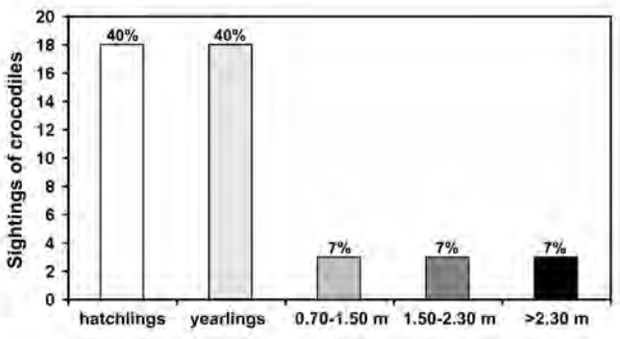


Fig. 4: Distribution of sighted yearlings of *Crocodylus porosus* (survey 2008).

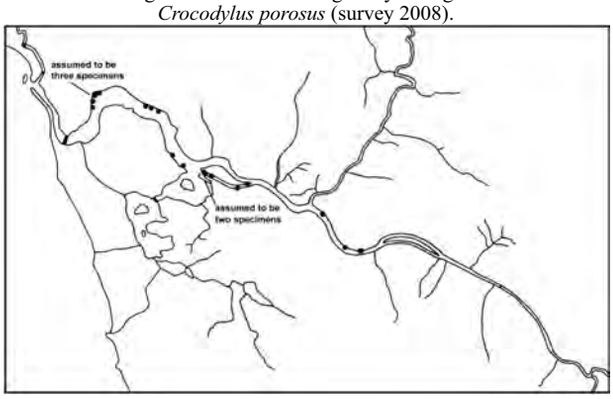
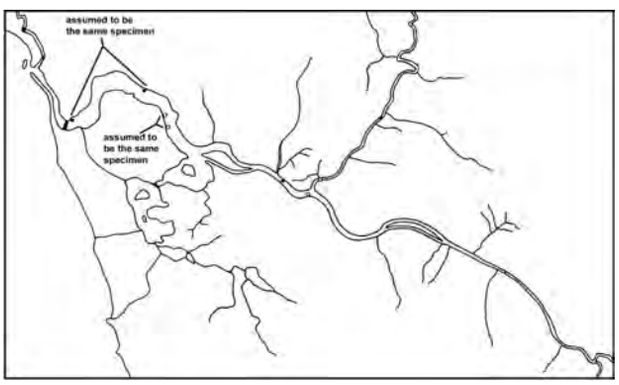


Fig. 5: Distribution of sighted *Crocodylus porosus* of the size classes 0.70-1.50 m (○) and 1.50-2.30 m (●) (survey 2008).

Fig. 6: Distribution of sighted adults of *Crocodylus porosus* (survey 2008).



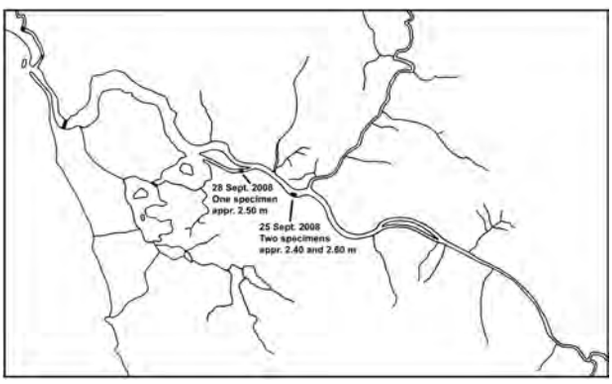
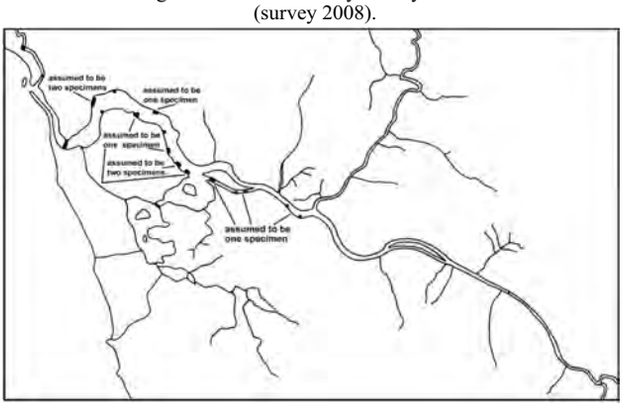


Fig. 7: Distribution of 'Eyes Only' counts (survey 2008).

Fig. 8: Map of the most part of the study area of the Bentota Ganga and localities of *C. porosus* during a preliminary survey on 23rd and 26th November 2007.



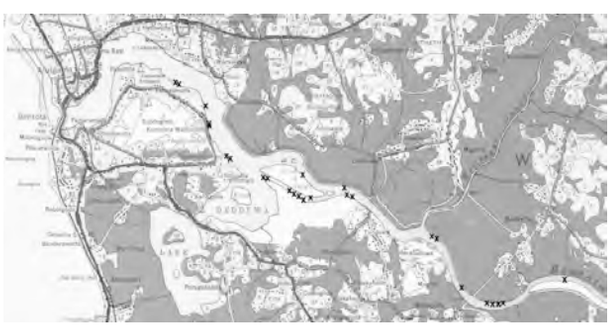


Fig. 9: Railroad bridge over a stream feeding the Dedduwa Lake.

Fig. 10: Association of sighted hatchlings and yearlings of *Crocodylus porosus* to bank vegetation (survey 2008).

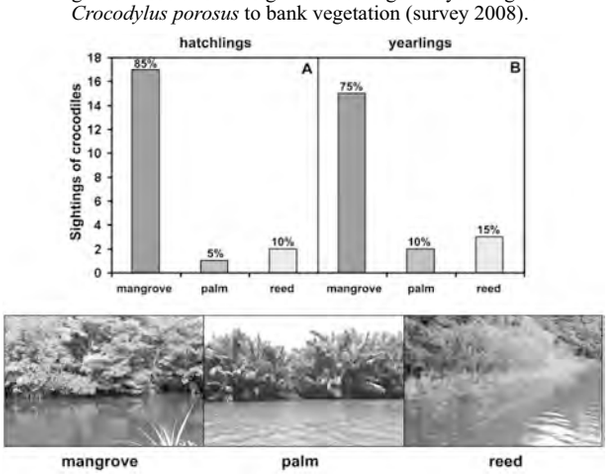


Fig. 11: Western part of the Bentota Ganga with the position of hotel buildings.

Fig. 12: Examples of disturbances in the lower section of the Bentota Ganga. A tour boating, B waterskiing, C jet skiing, D windsurfing.

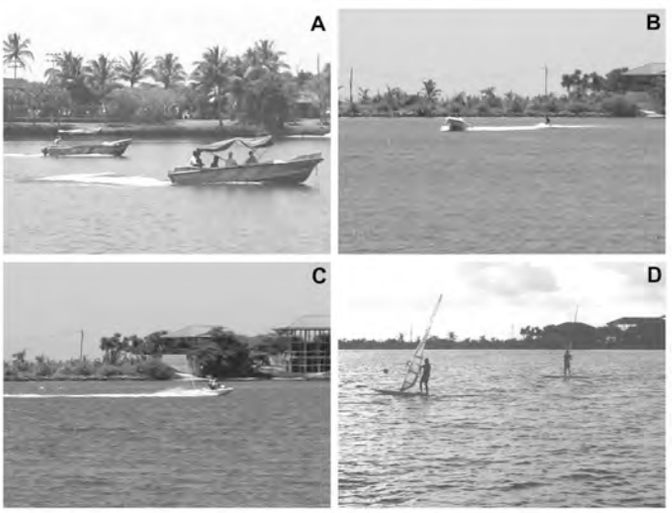


Fig. 13: Bentota Ganga and Welipenne Ganga showing disturbances and construction sites along the Bentota Ganga. A boat traffic, B water sports and diverse tourist activities, C fishing net, D sand collecting, E sand collecting, F motorway bridges.

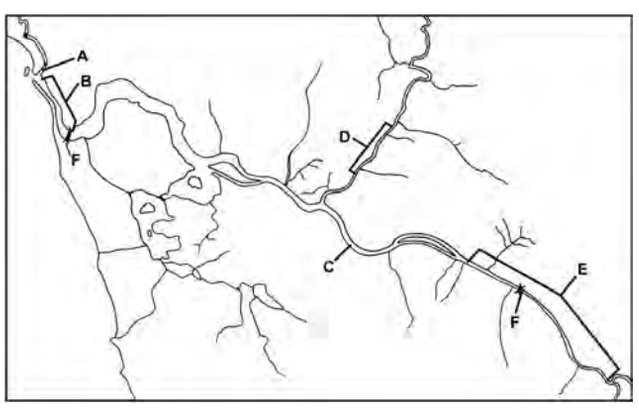


Fig. 14: Net stretched across the Bentota Ganga.

Fig. 15: Several boats collecting sand on the Bentota Ganga.

Fig. 16: Proposal for a warning sign (black letters and graphics on ochre background) in Sinhalese saying: “Attention. No swimming. Crocodiles in the water.”

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Crocodile conservation programme in Odisha, India with special reference To saltwater crocodiles, *Crocodylus Porosus* of Bhitarkanika mangrove ecosystem.

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Abstract

Crocodilians were threatened in India due to indiscriminate killing for commercial purpose and severe habitat loss until enactment of the Wildlife (Protection) Act.1972. All three species of crocodiles (Gharial, *Gavialis gangeticus;* Saltwater crocodile, *Crocodylus porosus and* Mugger crocodile, (*Crocodylus palustris)* in the river systems of Odisha were on the verge of extinction by the 1970's. Crocodile numbers were few because of ever increasing human activity in the rivers and their other traditional habitats, and consequent reduction in the extent of habitable stretches. Also, because of the fact that survival rate of the crocodile hatchlings in nature is low, because of predation.

With initiation of the Government of India/FAO/UNDP Project "Crocodile Breeding and Management" a Crocodile Conservation Project was launched in 1975 in different States. The Gharial, *Gavialis gangeticus* and Saltwater crocodile, *Crocodylus porosus* conservation programme was first implemented in Odisha in early 1975. Subsequently the Mugger crocodile, *Crocodylus palustris* conservation programme was initiated, since Odisha has the unique distinction of having all the three species of Indian crocodilians. The Conservation and Research Centres were established by the Forest Department, Govt. of Odisha at Tikarpada in Satkoshia Gorge Sanctuary, Dangmal in Bhitarkanika Wildlife Sanctuary/National Park and Ramatirtha in Similipal Wildlife Sanctuary for Gharial, Saltwater crocodiles and Mugger crocodiles, respectively. The main objective of the crocodile conservation programme was to quickly multiply the population using the "grow and release" techniques. During the last three and half decades, the 'rear and rehabilitation' of crocodiles at various centres have been carried out successfully.

The Saltwater crocodile operation has been a successful one and the crocodile population in Bhitarkanika river system has gradually been built up. As per the Jan., 2013 census in the river systems of Bhitarkanika sanctuary, there were 1661 crocodiles including more than 200 adult crocodiles. This is a over 16 times increase of crocodile population during the three and half decades. More than 60 released female Saltwater crocodiles have bred successfully and are laying eggs in the wild. This is a 12 times increase compared to mid 70s with respect to availability of crocodile nests in the wild.

At present, Bhitarkanika holds the largest population of Saltwater crocodiles in the wild in comparision to all its distributional range in India. It is to be noted that about 80% of the total Indian *C.porosus* population are available in the Bhitarkanika river systems of Odisha state.

This paper deals with the "conservation success" of the crocodile conservation programme, especially the Saltwater Crocodile 'rear and rehabilitation operation' in the mangrove ecosystems of Bhitarkanika in Odisha, India.

Introduction

The population three crocodilian species in India as well as in Odisha critically reduced due to combination of poaching and habitat loss (Bustard,1974,1975; Daniel and Hussain,1975; Kar,1978, Kar,1978,81,89; Singh etal.,1984) by the seventies. Piecemeal efforts were being made from the sixties onwards to save the crocodile. On request of Government of India, FAO Expert Dr. H.R. Bustard was appointed by UNDP/FAO to study on the prospects of crocodile rehabilitation in the river systems in 1974 and based on his report and guidance a Crocodile Conservation Project was launched in 1975 in different States.

During 1976, survey of (i) Saltwater crocodiles and (ii) Gharial crocodiles was conducted in the river system of Bhitarkanika area and in the Mahanadi, respectively. The number of Salt-water crocodiles in Bhitarkanika area was estimated to be 95, including 34 adults. The number of Gharials in Mahanadi was estimated to be 8, including 4 adults. No detailed survey was, however, conducted for Mugger crocodiles at that time, although the species occurred at several places in the State. The breeding population of Mugger known at that time was in the Balimela Dam in Koraput district.

An adult basking Mugger crocodile on the river bank of Satkosia Gorge

The Crocodile Project started with the objective of building the population and to make up the natural losses by death and predation through rear and release operation. This involved collection of eggs from the nests as soon as these were laid, incubation and hatching of these eggs in hatcheries under regulated conditions of temperature and humidity, rearing the young juveniles, marking and release of the young crocodiles into Nature in protected areas, and assessment of the degree of success in restocking any protected area with crocodiles released from the hatcheries. To accomplish these tasks, 3 separate research units were established at Tikarpara, Dangmal and Ramatirtha for the Gharial, Saltwater Crocodile and the Mugger, respectively. At the Nandankanan Biological Park, captive breeding plans for all three species were pursued.

Management Objectives

The broad strategy adopted for rehabilitation of crocodiles was to protect them in their natural habitats, to rebuild the population quickly through captive breeding (rear and release), and to build up trained personnel for the job. The broad objectives of activities under crocodile project were the following.

(a) To protect the remaining population of crocodilians in their natural habitat by creating sanctuaries.
(b) To rebuild natural population quickly through 'grow and release' technique.
(c) To promote captive breeding.
(d) To take-up research to improve management. Some of the major research activities have been in the following directions.

- Interpretation of the various types of data collected during survey and census.
- Determination of parameters for maximum success in egg collection, egg incubation, hatching, rearing and release, including husbandry aspects on feeding, food conversion and growth.
    - Study of habitat features and population structure.
    - Study of behavioural biology including reproduction, thermo-regulation, feeding, water-orientation, locomotion etc.

(e) To build up a level of trained personnel for better continuity of the project through trainings imparted at the project-sites and through the erstwhile Central Crocodile Breeding and Management Training Institute, Hyderabad.
(f) To involve the local people intimately through the following:

- The development of a strong level of acceptance of the project by the people, by locating the projects in rural areas where people could both see and participate in the entire programme.

- Protect the immediate and long-term interests of fishermen who reside within the sanctuaries, and whose livelihood depends on fishing, by, if necessary, providing an alternative source of income that was not detrimental to the conservation aims.

Project Sites In Odisha

Gharial project at Tikarpada
At Tikarpada, Gharial eggs were obtained at different points of time from Narayani and Kali rivers in Nepal and Chambal sanctuary in Madhya Pradesh, Rajastan and Uttar Pradesh. The eggs collected from Mahanadi were infertile. Some hatchlings of Gharial were obtained from eggs incubated in Royal Chitwan National Park of Nepal and Katarniyaghat sanctuary in Uttar Pradesh. All Gharials reared at Tikarpada and those produced from captive breeding at Nandankanan zoo, numbering more than 700, were released in the river Mahanadi between Boudh and Katrang.

An adult male Gharial with prominent "Ghara"

One of the assessments of the rear and release operation in respect of Gharials was made during December, 1987 - January, 1988, when only 25 Gharials were found to be surviving in the entire stretch of the river Mahanadi and down stream of Hirakud Reservoir over a length of 400 Kms. In January, 2012 census, two males and three female Gharials were sighted / counted in and outside of the sanctuary, respectively. A study was carried out to assess the reasons for poor survival of the Gharial in Mahanadi. For increasing the Gharial population to more viable levels it is absolutely essential to minimize fishing and navigation at least on certain stretches of the river. It has been under consideration to rehabilitate Gharials in Mahanadi up-stream of Hirakud reservoir, and some stretches of the river Brahmani.

Mugger project

The Ramatirtha center, meant for Mugger crocodiles, initially started with eggs and juveniles of Mugger procured from Tamilnadu. Since 1984 breeding of Muggers and the release of young ones into the nature in Similipal have been carried out, and so far more than 600 crocodiles have been released in Similipal.

(a) Census was conducted to ascertain the population status of Mugger crocodiles in the prominent rivers / water bodies such as West Deo, Budhabalanga, Khairi and East Deo inside the Similipal. A total of 82 Muggers were counted during 2012 census. The census result indicated that the two stretches namely UBK-Patbil and Kandadhenu- Lower Barhakamuda of the West Deo river were holding above 60% of total muggers in about 15 km of the river. This is the situation / trend continuing since late 1980s during which regular monitoring of the crocodiles has been carried out.

(b) An isolated population of about 40 Mugger crocodiles are now available in the Ghodahad Reservoir, which is an important tributary of the Rushikulya river in the Digapahandi range of Berhampur (T) Division of the Ganjam district.

Saltwater Crocodile Project

At Dangmal in Bhitarkanika Wildlife Sanctuary/National Park, Saltwater crocodile ('Baula' is the Oriya term for Saltwater Crocodile) eggs have been collected locally; and young crocodiles have been released in the creeks and the estuaries; and more than 2300 crocodiles have been released in phases since 1977(Kanungo,1976; Kar, 1978; Kar, 1981,1984; Behura,1999; Chadha and Kar,1999; Singh et al, 1984;Mohanty et al,2004; Patnaik etal,2012)

Basking male Saltwater crocodile (*Crocodylus porosus*)

This operation has been reasonably successful and the crocodile population in the Bhitarkanika river system has gradually been built up. Above 70 released female Saltwater Crocodiles have bread successfully and are laying eggs in the wild.

The annual census conducted in the river systems of Bhitarkanika wildlife sanctuary in January, 2013 indicated that there were 1661 Saltwater crocodiles and the crocodile population is on increasing trend. The details about the census results are as under:

Comparison of census results (2005 to 2012)

Hatchlings (<50 cm)	Yearlings (50-90 cm)	Juveniles (90-180 cm)	Sub-adult (180-240 cm)	Adult (240 cm+)	Total
486	356	396	128	295	1661
(29.48%)	(19.28%)	(25.74%)	(9.28%)	(16.22%)	(100%)

A juvenile partial white crocodile with a normal coloured crocodile

Size class	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Hatchlings	681	657	503	538	538	519	531	489	486
Yearlings	290	283	368	343	375	373	377	320	356
Juveniles	169	197	259	231	264	298	304	427	396
Sub-adults	107	122	135	143	148	156	166	154	128
Adults	207	203	232	261	271	281	292	269	295
Total	1454	1462	**1497**	**1516**	**1596**	**1627**	**1670**	**1659**	**1661**

The highlights of 2013 winter census are

(a) Bhitarkanika holds twelve (12) crocodiles of about 16-18ft. length, four crocodiles of 18-20ft. length and three crocodiles above 20ft. length.

(b) The areas (main Bhitarkanika river from Khola to Pathasala, Thanapati creek, Mahinsamada creek, Suajore creek, Baunsagada creek, Kalibhanjadia, etc.) having higher concentration of crocodiles fulfills the following basic requirements for survival of this endangered reptilian species:

(i) Good mangrove cover / fringing mangrove vegetations.
(ii) A network of creeks and creek lets.
(iii) Stretches of undisturbed mud banks as favored basking/resting spots.
(iv) Less human disturbance.
(v) Little or no illegal fishing activities.
(vi) Hypo -saline condition of water in the creeks, and
(vii) Depth of water (minimum 2.0 m at the lowest tide).

From the census results, 2013 as well as from the population trend, it is seen that the Saltwater crocodile population in the river systems in and outside the Bhitarkanika sanctuary is almost stable.

Management in the wild

Since the prime objective of crocodile project is to rebuild their population in the wild, restocking the sanctuaries with captive reared crocodiles is an ongoing programme. The resident and released populations of crocodiles are periodically monitored and the trend of nesting is also assessed.

Protection of crocodiles is a round-the-year activity. Measure threats are from intruding fishermen using nylon set nets which is most harmful for young and adult crocodiles.

Because of occasional reappearance of crocodiles in their former habitat that is now shared by increasing human population, there are occasional instances of nuisance crocodile. Such crocodiles are generally captured and shifted to some other river/creek or are brought back to captivity after careful consideration of the case histories and field conditions.

In the Bhitarkanika deltaic area, there are six Gram Panchayats consisting above one lakh human population reside surrounding the National Park area. More than 40% of the resident human population daily depend upon the National Park area for their livelihood. They illegally enter in to the tidal rivers and creeks for fishing using fishing nets of various mesh sizes and length, and also they collect fire wood as well as house hold materials form the forest. At times they swim in the tidal rivers with the logs and even they use hand made polythene boats to ferry big rivers. In the process, the people are attacked by the resident large males. Most of incidences of the crocodile attacks on humans recorded in the National park happened due to illegal entry of the people either for fishing or fire wood collection. Evidences were there that the fishermen managed to kill large male crocodiles of 19-20 feet length by putting illegally strong nylon nets in the potential crocodile habitats of Bhitarkanika river system, and even they had axed the head portions of the crocodiles.

The State Wildlife Organisation is very much concerned and taking all possible steps to prevent human-crocodile incidents. It is now essential to bring up a 50 metre strip of mangroves along all the creek and river banks in and outside the National park , which will ensure a total separation of crocodiles from people and domestic live stock.

Captive breeding of crocodiles at Nandankanan

Captive breeding units on all the three crocodilian species have been established at Nandankanan Zoo (Acharjyo et al, 1996 a,b,c; Kar et al, 1998). Muggers bred at Nandankanan Zoo have also been released in Satkosia Gorge. Gharials bred for the first time in Nandankanan in 1980, which was a world record. Although Gharials have failed in establishing in Satkosia Gorge, Muggers have settled down well in this stretch of Mahanadi River. As per survey carried in January to March 2012 there are 91 Muggers in Mahanadi system

Research and training

In-house research has been conducted to standardise 'the rear and release' technique. Studies have been carried out to determine the appropriate method of population assessment, egg collection, egg incubation, hatching, and husbandry of the young crocodiles and various aspects of behavioural biology of the three species of crocodiles and their habitat features (kar and Bustard,1991;Kar and Patnaik,1998; Mohanty etal,1984). The baseline data on Indian crocodilians and their management has been possible because of over 300 publications produced from these conservation projects.

Training has been imparted to all field staff employed in the project to help them to discharge their duties efficiently. Local people have been trained on how to bring live food for the hatchling in the pools.

Contributions

All the three species of crocodiles have been saved from the brink of extinction, and many of their habitats have been brought under the protected area network of the state. The crocodile project that has since long come to a slow-pace in the

State has contributed immensely to develop the know-how and spreading of awareness. Study on the ecology and biology of the Saltwater crocodiles emphasizes the presence of mangroves to be the most important facet of environment for the crocodile species. Loss or depletion of mangrove forest causes either complete extermination of the population or draw the population to the verge of extermination. The climate and the mangrove ecosystem are the factors for survival of the Saltwater crocodiles. Future of the crocodiles can be secured with adequate protection of their habitats.

Apart from producing a large number of crocodiles in a short span, the Crocodile Project has contributed in various ways to the entire approach of wildlife conservation, research and training.

- Local people have been intimately involved in the management of crocodiles.
- Full time research personnel have been inducted into the wildlife wing to carry out research on crocodiles and other associated wildlife.
- Some important wetland sanctuaries have been created with crocodiles as the flagship-species.
- Active management of other wetland species began in conjunction with the crocodilians. These included the mangrove plants, marine turtles, freshwater turtles, monitor lizards, Gangetic dolphins, Irrawaddy dolphins, otters and other reptilian fauna.
- Along with the crocodile project there began an intimate overseas collaboration in the field of wildlife conservation, education and training.

Acknowledgements

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References

1. Acharjyo,L.N.; Kar,S.K. and Patnaik,S.K.(1996a): Role of Nandankanan Biological Park, Orissa in conservation of the Gharial (Gavialis gangeticus). Tiger Paper.23(3): 5-8.
2. Acharyo, L.N.; Kar, S.K. and Patnaik, S.K. (1996b): Studies on captive breeding of the Gharial, Gavialis gangeticus (Gmelin) inOrissa. J.Bombay nat.Hist.Soc.93(2):210-213.
3. Acharjyo,L.N.;Kar,S.K. and Patnaik,S.K.(1996c): Observations on Breeding of Mugger (*Crocodylus palustris*) at Nandanakanan Zoological Park, Orissa. Cobra.26:1825.
4. Behura, B. K. (1999). Bhitarkanika- The wonderland of Orissa. Nature and Wildlife Conservation Society of Orissa. Bhubaneswar. pp.1-63.
5. Bustard, H.R.(1974): India. A preliminary survey on the prospect of Crocodile farming. FAO. Rome (FO. IND/71/033). Pp. 1-50.
6. Bustard, H.R. and Choudhury, B.C. (1980): Parental care in the Saltwater Crocodiles (Crocodylus porosus) and management implications. J. Bombay nat. Hist. Soe. 77 (1) 64-69.
7. Chadha, S. and Kar, C. S. (1999): Bhitarkanika: Myth and Reality. Natraj Publishers, Dehradun . pp.1-388.
8. Daniel, J.C. and Hussain, S.A. (1975) : A record (?)saltwater crocodile, Crocodylus porosus (based on their study in Bhitarkanika during 1973). J. Bombay nat. Hist. Sco., 71 (2). 309-312.
9. Kanungo, B.C. (1976): An integrated Scheme for Conservation of Crocodiles in Orissa with Management Plan for Satkosia Gorge and Bhitarkanika Sanctuaries. Forest Department, Govt. of Orissa, Cuttack. Pp. 1-128.
10. Kar. S.K. (1978): Saltwater Crocodile Resources in Orissa. Orissa Review. 35 (3): 50-52.
11. Kar. S.K. (1981): Studies on the Saltwater Crocodile, Crocodylus porosus Schneider. Ph.D. Thesis submitted to Utkal University, Bhubaneswar, Orissa, India.
12. Kar. S.K. (1984): Conservation future of the Saltwater Crocodile, *crocodylus porosus* Schneider in India. IUCN publications New Series. Proceedings of the 6th Working Meeting of the Crocodile Specialist group. Pp.29-32.
13. Kar, S.K. and Bustard, H.R. (1982): Occurance partial albinisan in a wild population of Saltwater crocodile (Crocodylus porosus Schneider) in Bhitarkanika Wildlife Sanctuary, Orissa, India. Brit. J. Herpetol. 6:220-221.
14. Kar, S.K. and Bustard, H.R.(1991). Status of Saltwater Crocodiles, Crocodylus porosus Schneider in Bhitarkanika Wildlife sanctuary, Orissa, J.Bombay nat. Hist. Soc. 86(2):141-150.
15. Kar, S.K. and Patnaik, S.K. (1999): Status, Conservation and future of Saltwater crocodile in Orissa. Envis (Wildlife and Protected areas). Wildlife Institute of India, Dehradun. June, 1999. 2(1): 24-28.
16. Kar, S.K.; Acharjyo,L.N. and Patnaik, S.K.(1998): Rehabilitation of crocodilians in Orissa. Cobra.33:23-26.
17. Kar, S.K,.(1984): Conservation future of the Saltwater crocodile(*Crocodylus porosus* Schneider) in India. Crocodiles. Proc.of the 6th Working Meeting of the Crocodile Specialist Group of the IUCN/SSC. Victoria Fall, Zimbabwe and St.Lucia Estuary, South Africa. 19-30 Sept.1982. pp.29-32.
18. Mohanty, S.C.; Kar, C.S.; Kar, S.K. and Singh, L.A.K. (2004): Wild Orissa-2004. Wildlife Organisation, Forest Department, Govt. of Orissa, Bhubaneswar. pp. 1-81.
19. Patnaik,S.K.; Kar,C.S. and Kar,.S.K.(2012):Mangrove ecosystem of Orissa with special reference to Bhitarkanika. In: N. K. Mahalik ed. Coastal Tract of Odisha: Geology,Resources and Environment.pp.217-240.
20. Singh, L.A.K, Kar, S.K. and Choudhury, B.C. (1984): India. Status of wild crocodilians. Proceedings of the 7th working meeting of the Crocodile Specialist Group. IUCN publication. New series. Pp. 355-361.

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East African holotype in Colombo, Sri Lanka

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Abstract

The original subspecies *Crocodylus niloticus pauciscutatus* Deraniyagala, 1948, was from East Africa at Lake Rudolf (Lake Turkana) in Kenya and adjacent Ethiopia. It is based on a holotype, and its type description is compared with the newer (1974 and onward) CITES version of the same name. The type material of *C. n. worthingtoni* Deraniyagala, 1948, and *Crocodilus multiscutatus* Rüppell, 1826, from Kenya and Sudan respectively, is also discussed, and specimens from Egypt, Madagascar are mentioned, and Adanson's "Crocodile vert" from the Senegal River is illustrated. Various problems involved with counting the dorsal, ventral and flank scales in African mesorostrine crocodilians are detailed.

Introduction

Until 1974, the subspecies *C. n. pauciscutatus* was pretty much ignored, but when CITES recognized this species-group name it became more than a hypothesis that could be listed as merely a junior synonym of *Crocodylus niloticus* without subspecies, at least temporarily. Therefore I evaluate the specimen basis for this name, and examine the characters that were claimed to distinguish the original 1948 *C. n. pauciscutatus* as a taxon. My conclusion is that this name is available in zoological nomenclature. However, its type description was internally inconsistent and with a remarkably small sample, and the reason he called the Lake Rudolf (= Lake Turkana) crocodile as *pauciscutatus* withstands neither close scrutiny not larger sample sizes from the type locality. Some old information from Rüppell (1826) and Deraniyagala (1948) about the dorsal scales on the body and neck of Nile River crocodiles from Egypt and Sudan is relevant, as is also some Ross & Mayer (1983) and other data about Madagascar. Explicit and substantive references are made to photographs in Graham & Beard (1973) that are not reproduced here, but that book was reprinted in 1990 by Chronicle Books in San Francisco, California.

Discussion

In a paper published in Sri Lanka (then Ceylon), of which the section titled"Probable new races of Nile Crocodile" is an included short part (pages 30-31, & figure 2 on plate 12), Paul E.P. Deraniyagala (1948) routinely and deliberately designated holotypes "type" and paratypes. However, in the type description of *Crocodylus niloticus pauciscutatus* Deraniyagala, 1948, he designated only a holotype, and it was "Colombo Museum specimen No 1" which is "the skin of an adolescent from Lake Rudolf presented by Mr. A. L. Griffith, the Assistant Superintendent of Police, at Lodwar, Turkana district, East Africa" and 161 cm long (not the animal's total length, but rather that of the incomplete skin). The scientific name of the Lake Rudolf or Lake Turkana crocodile is based entirely on this headless hornback hide. It was clearly stated that the holotype skin "had been removed by cutting along the mid ventral line" and that its head and the distal part of the tail were missing (Deraniyagala, 1948). Less clear is the nature of the "two adult skins from Lake Rudolf made available to me [i.e., to P.E.P. Deraniyagala] by Mr. L. E. Whitehouse" which Deraniyagala examined in Kenya. The ventral scales of the two Whitehouse specimens were reported in Deraniyagala (1948), although partly worded incorrectly. His table 6 category "Number of transverse rows of belly scales" (sic) must mean the number of truly ventral scales in the transverse row at the level of the widest part of the belly (what I often call "midbody" or "midbelly"). Probably redundantly his table 6 "Abdominal transverse scale rows" (sic) category appears to mean the same thing. In any event, the Deraniyagala (1948) text data about there being approximately 20 single-crested caudal whorls appears to be based on specimen(s) other than the holotype, and there were two of them (columns A & B in his table 6) owned by Mr. Whitehouse, of which the tail was complete on only one (the column A individual). The collar-vent count on the holotype skin is unknown, and so also is the transverse count of truly ventral scales across the widest middle level of the belly. However, the "type-skin" was reported in his table 6, column C, to have 19 double-crested caudal rows in its dorsal armor. Separately it was also said in table 6, column C to have 16 transverse dorsal rows on the superior surface of the body, which is different from his text characterization that in this subspecies "the dorsal scutes are in fifteen transverse rows from the neck to the back edges of the thighs" (Deraniyagala, 1948), when actually it was only the Whitehouse individual with a complete tail (column A) that had 15 dorsal body rows. The other Whitehouse adult (col. B) and separately the holotype juvenile (col. C) both had 16 dorsal transverse rows on their "body" (as opposed to the neck and the tail). Thus, the holotype data in his table 6 (number of transverse dorsal scute rows = 16) contradicts his "fifteen transverse rows from the neck to the back edges of the thighs" but, in contrast, this same table 6 data does not contradict his later text

characterization that in *C. n. pauciscutatus* “there are generally 15 or 16 transverse rows of dorsal scutes” on the body (Deraniyagala, 1948). In addition to examining three skins from Lake Turkana in Kenya, one of which was later deposited in the Colombo Museum, Mr. Deraniyagala (1948) also examined an unknown number (“several”) adult skulls, and as evidenced by his written description of the lower teeth and selected bones of the lower jaw, and his plate 12, figure C illustration, at least one of the skulls had its mandibles. Thus, because the holotype skin was headless, it is certain that all of the information concerning the head of *C. n. pauciscutatus* was based on other specimens which, although mentioned in the type-description, are not official paratypes of the name. Similarly not paratypes are the “three Lake Rudolf specimens now in the British Museum and numbered D. E. F. in Table VI” (Deraniyagala, 1948) which were examined by H.W. Parker at the BM(NH), and not by P.E.P. Deraniyagala. It was good scientific practice for Deraniyagala (1948) to designate a Colombo Museum specimen from Lake Rudolf as a holotype, while simultaneously not designating as paratypes the other Lake Rudolf material that was known to him (but not owned by him), and separately some Lake Rudolf specimens in London, England, reported to Deraniyagala only in words and numbers by Mr. Parker. The species-group name *Crocodylus niloticus pauciscutatus* Deraniyagala, 1948, is based in zoological nomenclature upon one unique and incomplete individual animal. Thus, Ross (2006) was technically wrong about there being belly scales data about a “type series of the name” (sic), because there was no belly scales data from the holotype (a type-series of 1) in Deraniyagala (1948). In Ross (2006) the two Whitehouse skins were mistakenly treated as paratypes, which they definitely are not. Despite my 2006 error, the basic Ross (2006) question remains unchanged about whether or not the two standard kinds of ventral scale counts on the holotype of *C. n. pauciscutatus* identify it correctly to subspecies in the old official identification manuals for CITES regulated crocodilians.

Separately there is a statement in Ross (2006) which alleged that the *Crocodylus n. niloticus* material that Deraniyagala (1948) distinguished as different from the Lake Rudolf crocodile was from “Faiyum, Egypt” (the Fayum). That assertion was based on information in the introduction to the paper, and I had overlooked two specimens of *C. n. niloticus* explicitly cited in the crocodiles essay as “an adult skin at the headquarters of the Southern Area Camel Corps at Assuan, and another at Wadi Halfa” (page 30 in Deraniyagala, 1948). These two are the skins that formed his southern Egypt (Aswan on the Nile) and northern Sudan (Wadi Halfa on the Nile) sample for comparison with the skins in Turkana, Kenya, at Lake Rudolf.

The Aswan and Wadi Halfa skins each had 17 dorsal transverse body rows according to counts made by Paul Deraniyagala himself at those places, or possibly from his own photographs. The difference between 17 dorsal body rows for these two Nile River animals (n=2), compared with the 15-16 that he counted on Lake Rudolf animals (n=3) was the justification for naming one of the two Lake Turkana skins with 16 rows as *pauciscutatus* meaning few scaled (16 on the holotype) compared with many scaled (17 transverse body rows). The latinized term for many scaled is “multiscutatus”, and both Aswan and Wadi Halfa are geographically located very near to the type-locality of *Crocodilus multiscutatus* Rüppell, 1826, which is the Nile River in northern Sudan (probably known to Deraniyagala indirectly through Boulenger's or someone else's synonymy listing). In his 1825 letter from Dongola, today the capital city of the state of Northern in the nation of Sudan, Eduard Rüppell (1826) asserted that there are two species of Nile River crocodiles in the Dongola (actually Sukkot or Soucot) region, which itself is located between the Nubian Desert and the state of Northern Kordofan. These two species were “*Crocodilus vulgaris*. Lin.” (today *C. vulgaris* Cuvier) and his own new *Crocodilus multiscutatus*. Both of Rüppell's species exhibited the same number of transverse dorsal rows on the body, namely 16 each. The reason that Rüppell (1826) employed the name “*multiscutatus*” was not to denote the number of transverse dorsal body rows (which is the same 16 in both of his Dongola taxa), but rather to denote a remarkably large number of scales within the individual transverse row across the animal at the midbody level (at or near PC-12) where the dorsal armor is its widest.

Thus, the name *C. multiscutatus* Rüppell reports a transverse count across the dorsal surface at or near PC-12 (“midbody”), while in contrast *C. n. pauciscutatus* Deraniyagala reports a lengthwise count of dorsal transverse rows located between but not including the neck and the tail, with the dividing line between body and tail being the transverse level of the rear edges of the thighs in Deraniyagala (1948), but Rüppell (1826) did not define where the body stops and the tail begins.

Given the coincidence that Rüppell (1826) said 16 transverse rows on the body for all of the *Crocodylus* in the Nile in northernmost Sudan, and Deraniyagala (1948) said 16 transverse dorsal body rows for his Lake Rudolf holotype, it becomes important to note that Deraniyagala's (1948) Turkana, Kenya, animals (n=3) were reported as 6 scales across at midbody when Deraniyagala (1948) said that in his *C. n. pauciscutatus* “the contiguous dorsal scutes are arranged in 3/3 longitudinal series. Ventrally the two median rows are noticeably larger than the others. The specimens examined were three skins and several adult skulls”. Thus, the 3/3 data is a generalization, as opposed to a direct report of the number of dorsal scales that are contiguous with each other as a transverse row at the widest level across the body on the holotype specimen. Clearly neither his ventral nor his dorsal scalation generalizations are direct reflections of the holotype, and all of his observations about the head, and his information about the maximum adult size of the crocodiles in Lake Turkana, is also not based directly on this holotype individual.

What Rüppell (1826) said about *Crocodylus* in the Nile River in northern Sudan is that some (namely *C. vulgaris*) have 6 scales across (presumably 3/3) at midbody, while others (namely *C. multiscutatus*) have 10 scales (presumably 5/5) in the corresponding transverse dorsal row. I do not understand exactly how Eduard Rüppell counted his 10 scales across the back, but I have seen 9 contiguous dorsals at or near the midbody level (actually in PC-12 only) in *C. niloticus* rarely (Ross & Mayer, 1983). Because Rüppell (1826) is a very obscure paper and printed in a difficult German typeface, it is almost certain that Paul Deraniyagala did not know that *C. multiscutatus* Rüppell referred to the breadth of the midbody carapace. Probably all that he knew (if anything germane) was that the type-locality of *C. multiscutatus* was the Nile River in northern Sudan (near Wadi Halfa and Aswan). He did not know that Rüppell (1826) had reported 16 transverse dorsal body rows on all of the crocodiles in the Dongola (Soucot or Sukkot) area.

The dorsal character said to distinguish *C. n. pauciscutatus* (defined as Lake Turkana) from *C. n. niloticus* (defined as Wadi Halfa and Aswan) does not work, unless Rüppell's definition of what qualifies for counting as a dorsal transverse row was different from Deraniyagala's. Further, when Deraniyagala (1948) said that "Mr. H. W. Parker informs me that three Lake Rudolf specimens now in the British Museum and numbered D. E. F. in Table VI, possess 16, 16 and 17 rows", he appeared to accept that data, and if so it too contradicts the simplistic dichotomy that 15 or 16 means Lake Rudolf, while simultaneously 17 means not Lake Rudolf. However, ambiguity at the thoracic and sacral ends of this lengthwise counting character casts doubt about the homology of different men's (Deraniyagala's, Parker's and Rüppell's) counts of the number of transverse rows crossing the body.

On whole animals the traditional method of finding the sacro-caudal juncture by the back legs sometimes arrives at the same result as the Ross & Mayer (1983) method, but not always. Other specimens such as flat skins and stuffed animals present special problems. There is a Ross & Mayer (1983) recommended way to find precaudal row #1 (PC-1) and caudal row #1, but it was not employed by Deraniyagala (1948), and it was presumably applied by neither Mr. Parker (in Deraniyagala, 1948) nor E. Rüppell (1826). The parsimonious presumption is that all of these men employed the same hind-legs definition for the division between the body and the tail, but it is unlikely that their specimens were all flat skins. The hind leg on a whole animal is presumably significantly different from the hind leg on a flat skin. If this is not true, then someone should demonstrate it. Also, exactly what the back edge of the thigh means needs clarification, because it is different at the juncture with the body, compared with further out along the femur.

In *Crocodylus niloticus* "there are 16 or 17 continuous rows of precaudal armor, with four to nine, usually six, scutes per transverse row at midbody. The median scute pair of the anteriormost thoracic row is often enlarged" (Ross & Mayer, 1983). However, table 1 in the same 1983 paper showed that rarely a result of only 15 dorsal body rows was encountered (PC-16 has a mode of 6, and a range of 0-6). Also I newly note that the Senegal River stuffed specimen illustrated as figure 1 in Ross (2012a) has an obvious and normal sized anteriormost thoracic row, and then anterior to it is a vestigial row that some people might count as a transverse body row present, while other people might consider it absent because the scales are so much reduced in size and number. It is just a pair of tiny scutes on Adanson's "Diasik" or "Crocodile vert" MNHNP 0.7524, and this ancestral transverse thoracic row can be seen near the extreme left edge of the photograph below (Figure 1) in the present paper.

There is a similar but more obvious anteriormost thoracic transverse row situation on a Lake Rudolf *Crocodylus niloticus* shown in a photo on page 62 of Graham & Beard (1973). This reduced and interrupted row is located between the shoulder blades and consists of a contiguous pair of median scales and also a detached smaller scale on the ends of a vestigial transverse row (reduced from 6 to 4 by internal deletions). On this individual Lake Rudolf or Lake Turkana animal there are three transverse rows of nuchals, but the description based on three skins in Deraniyagala (1948) indicates a nuchal cluster of two transverse rows. The posteriormost of the three transverse rows of nuchals is not obligatory in the Nile crocodile. Sometimes it is present to a variable degree, and sometimes it is completely absent. The Graham & Beard (1973) page 62 Lake Turkana crocodile has the posteriormost row of nuchals present as fully expressed scutes in a pair, and 2 is the maximum normally expected in this cervical row (PC-19) on this species.

There is a page 90 photo in Graham & Beard (1973) that shows the complexity of the osteoderms in the cervico-thoracic juncture region on another Lake Rudolf *Crocodylus niloticus*. There is good reason to question the simplicity of the dorsal scale counts on the body in Deraniyagala (1948) and also those in Rüppell (1826) and the majority of other more recent reports about the living northern African mesorostrine crocodilians.

It was implied in Deraniyagala (1948) that Lake Rudolf *Crocodylus* have a transverse space of unarmored skin separating their nuchals from their thoracic and body armor. This is true in the page 90 photo in Graham & Beard (1973), but apparently not so in their page 62 example which has its cervical and thoracic rows essentially continuous, and thus not separated from each other by a broad band of flexible skin at the cervico-thoracic juncture. The page 62 animal has PC-19 present as 2 scutes, but the thoracic row immediately adjacent and posterior to it is probably not PC-18, because table 1 in Ross & Mayer (1983) said that PC-18 has a mode of 0 and a range of 0 in *Crocodylus niloticus*. The anteriormost transverse thoracic row on this individual should (in theory) be PC-17. However, I would need to at least see the sacral region more closely, and better yet feel the perpendicularly outstretched femur bones of the hind limbs, and separately the iliac crests of the pelvis, to say for sure that PC-18 is not the body row in question.

Separately perplexing is the Deraniyagala (1948) dichotomy of "median rows of ventral scutes not enlarged" in *C. n. niloticus*, compared with "median rows of ventral scutes enlarged" in *C. n. pauciscutatus*. This character presumably refers to the median pair of scales in appropriate transverse rows, but in a picture on the bottom of page 246 in Graham & Beard (1973) the dimensions of the scales bordering the long-axis ventral midline of the animal do not look differentially enlarged compared with their neighbors. To the contrary, there is a remarkable degree of regularity (approaching three dimensional reflective symmetry) in "the two median rows" and their general region on at least the midbody part of the belly (see also the pages 118-119 photo in Graham & Beard, 1973). Based on experience, I do not characterize the belly scales as occurring in longitudinal rows, but rather as transverse rows only, and actually they are not truly transverse rows. The midline phenomenon along the length of the belly has an embryological complication and this makes it prone to anomalies. Therefore I prefer to perform the collar-vent count a full scale away from the midline (the Bronx Zoo method), once on each side to purposefully avoid the median pairs of elements, as explained in Ross (2012c).

There is an old and rare book by Karlheinz Fuchs in which Madagascan *Crocodylus niloticus* (his "Croco Mada" ventral skins) were alleged to exhibit a "double row of broad scales found along each side of the ventromedian line" and resemble the commercial skin of East African animals on the mainland (his "Croco Afrique" belly hides) in some ways. However, as documented in Ross (2012b), Mr. Fuchs (probably written in 1973) did not say that these especially broad pairs of scales are characteristic of *Crocodylus niloticus* in Kenya, nor in a tiny part of adjacent Ethiopia (nor a corner of South Sudan) at the northern end of Lake Turkana.

The fact that the number of transverse rows in the collar-vent count, and the maximum number of scales in a truly ventral row across the belly were reported for the two Whitehouse skins (presumably hornbacks, but not stated), but not the holotype skin (definitely a hornback) suggests that the ventral long-axis midline on "Colombo Museum specimen No 1" was damaged during preparation. It is unknown whether or not the cloacal oval is present, and peripherally there is ambiguity about whether or not any of its paws are present. The exact incompleteness of the holotype of *C. n. pauciscutatus* Deraniyagala, 1948, needs being explicitly reported, but it is known that the tip of its tail is missing after the 15th dorsal transverse row posterior to the sacro-caudal juncture, which in Deraniyagala (1948) was defined as the level of the back edges of the thighs. The level where the body stops and the tail begins is alternatively determinable the Ross & Mayer (1983) way for flat skins, stiffed animals, and on selected photographs. The results of the two (1948 and 1983) methods might be slightly different. If anyone has done scale counts on the Colombo Museum skin from Lake Rudolf, the method of identifying the sacrocaudal juncture in the dorsal armor deserves special and explicit explanation. Similarly the definitions employed in performing ventral counts on the belly skin should be noted (see Ross, 2012c). The Ross & Mayer (1983) dorsal armor method was designed primarily for whole animals that have their pelvic and femur bones inside them, and on which these bones can be manually felt through the skin and muscle. Unfortunately only one of the three Ross & Mayer (1983) ways of finding the sacro-caudal juncture works on flat skins and from specially detailed photographs.

In the two cited dorsal view photos in Graham & Beard (1973) it is difficult to see exactly which transverse row in the pelvic region is the first to slightly broaden, going posteriorly towards and onto the tail, and therefore I can not reliably locate the sacro-caudal juncture on these two photos. Thus, because the location of PC-1 is uncertain, it is impossible for me to assign a precaudal number to the anteriormost thoracic row. However, my best guess is that their page 62 animal has 17 precaudal rows present, and judging from the right edge where the hind leg had formerly been, my guess is that the third row from the bottom on the page 90 picture is PC-1, because after the body armor narrows and crosses the pelvis, it is this row that seems to slightly widen. If correct about PC-1, then the anteriormost thoracic row (with two median scales contiguous with each other) is PC-17. In this same page 90 photo the single vestigial osteoderm surrounded by flexible skin in the cervico-thoracic juncture region is unassignable to transverse row. It could be a remnant of the anteriormost thoracic row theoretically possible in the Crocodylia (PC-18), or alternatively a fragment from the posteriormost cervical row possible in the Crocodylia (PC-19).

It was recently said that in *Crocodylus niloticus* "the dorsal scales, which are not directly adjacent to the nuchals, are arranged in 6-8 longitudinal and 17-18 transversal rows" (Trutnau & Sommerlad, 2006). In my opinion it is a seriously misleading and major oversimplification to say that the dorsal body scales are arranged in longitudinal rows. Rather, what they intended to say is that there can be 6-8 longitudinal keel rows at the general midbody level, but always 4 at the pelvic level (PC-1 and PC-2), and often less than 6 at the anterior end of the thoracic series.

There was no definition of exactly where the body stops and the tail begins in Trutnau & Sommerlad (2006), except their figure 13 (and its corrected caption), which is very vague. Problematically, the Trutnau & Sommerlad (2006) assertion that 18 transverse rows are possible on the body in *Crocodylus niloticus* might (hypothetically) in some cases be true when the back-legs thigh level is employed as the method of finding the posterior end of the "body" as opposed to the tail, but in contrast it still remains true that the Ross & Mayer (1983) prediction is that, when defined by its vertebral correspondence, PC-18 is always absent or reduced to a single scale or less in the Nile crocodile species.

There are four color pictures (figures 142, 150, 359 and 360) alleged by Trutnau & Sommerlad (2006) to be *Crocodylus niloticus pauciscutatus*, but none of the four are explicitly animals from Lake Turkana. Three are "Masai Mara, Kenya"

(near Lake Victoria, and far distant from Lake Rudolf) and one is just "Kenya" for locality. The Trutnau & Sommerlad (2006) distribution for their *C. n. pauciscutatus* included all of Kenya, but it was unclear in Deraniyagala (1948) about whether or not his *C. n. pauciscutatus* occurred anywhere other than Lake Rudolf, Turkana, itself. Paul Deraniyagala (1948) examined a specimen from Lake Victoria, but he did not say that Lake Victoria has the same subspecies of *Crocodylus niloticus* as Lake Rudolf. He did, however, suggest that Lake Baringo in Kenya's Rift Valley has a different subspecies (*Crocodylus niloticus worthingtoni* Deraniyagala, 1948), which was said to be small adult animals (which is unlike Lake Rudolf, Lake Victoria and elsewhere). Further, he noted that Mr. Parker's examination of the BM(NH) material from Africa (no details, but implicitly not Lake Rudolf) revealed 17 transverse body rows on eleven, and 15 transverse body rows on one. That 15 result is perplexing, but I interpret Deraniyagala (1948) as saying that the Lake Turkana crocodiles have fewer body rows than *Crocodylus niloticus* in Egypt, Sudan, and pretty much the rest of Africa, including Lake Victoria. His 17 rows data from the BM(NH) implies that Deraniyagala (1948) was not saying that Lake Turkana and everything south and west of it (such as Madagascar, South Africa and Senegal) is the*C. n. pauciscutatus* kind. Therefore I today consider the species-group name *pauciscutatus* Deraniyagala, 1948, restricted to its type locality. There is a figure 6c illustration in Ross & Mayer (1983) showing a *Crocodylus niloticus* from Madagascar (MCZ 12552) which lacks an narmored space clearly separating its nuchals from its thoracic scales. Concerning this phenomenon, Ross & Mayer (1983) said that "in some individuals, especially from Madagascar, a row of two scales intervenes between the thoracic and cervical armor. We interpret this as PC 19 on the basis of its being closer to the cervical than the thoracic armor, but this identification is not certain". Thus there are at least two places in Africa where the Trutnau & Sommerlad (2006) characterization that the nuchals are not directly adjacent to the dorsal body armor in *Crocodylus niloticus* does not always work. For reasons discussed in Ross (2012b, 2012c), it was a surprise to Andy Ross and me that *Crocodylus niloticus pauciscutatus* Deraniyagala, 1948, ever became a CITES regulated crocodilian taxon. It had not been actively employed between 1948 and 1974. Note that the bibliographic listing on page 256 in Graham & Beard (1973) is wrong about one detail. The pagination of the Deraniyagala (1948) paper is not pages 31-32, which are merely the crocodile part.

As an example of the status of *C. n. pauciscutatus* before 1974, the words "*pauciscutatus*" and "subspecies" and "Ceylon" are not in Graham & Beard (1973). Further, Deraniyagala's name does not appear in their text. Separately, although Baringo was mentioned as a lake (through which an explorer passed), Graham & Beard (1973) did not mention the Lake Baringo crocodile hypothesis (*C. n. worthingtoni* Deraniyagala, 1948). In Fuchs (2006) the identification character "Number of lateral scale rows" was defined on his page 16 as "The clearly visible longitudinal rows are precisely counted on the transverse row midway between the posterior rim of the collar and the anterior rim of the cloacal vent. Determination of the size, the degree of ossification and lengthwise keels". He appeared to be reporting the number of enlarged flank rows encountered at midbelly and midbody level, as opposed to the number of scutes within any individual flank row. Thus I interpret Fuchs (2006) as indicating 3 or 4 lengthwise rows of enlarged scales in the flank skin at midbody in his own expanded version of *Crocodylus niloticus pauciscutatus* from 1974, which theoretically should include the 1948 original. However, there are more than 4 scutes in each of the obvious two flank rows on the Lake Turkana giant on the book's covers and pages 186-187 in Graham & Beard (1973).

Because Fuchs (2006) was working from the belly going outwards onto the flank skin, his "outermost" flank row is the one farthest from the animal's long-axis ventral midline. About *C. n. pauciscutatus* he said "Number of lateral scale rows: 3-4 large scales, keels on the outermost longitudinal row towards the dorsal scutes. Granular scales irregularly scattered between the large scales". Indeed, in the Graham & Beard (1973) germane photo there is a strip of granular scales separating the contiguous dorsal armor from the dorsalmost flank row, and similarly a band of granular scales separating that proximal flank row from the slightly more distal flank row parallel to it, and further there is a lengthwise zone of granular scales distal to that second flank row. Separately this Graham & Beard (1973) covers and pages 186-187 crocodile has a few granular scales within each of its two obvious flank rows, separating some but not all of the scutes within each row from its neighbors in the same row. The Fuchs (2006) data about the number of lateral scale rows in *C. n. pauciscutatus* appears to me to not describe what I see on this individual Lake Rudolf animal.

Therefore, in an attempt to better understand the meaning of this Fuchs (2006) character, I looked at his "*Crocodylus suchus*" (sic) account on page 113, which says "Number of lateral scale rows: 4-5 large scales, keels more or less strongly developed on all scales. Granular scales scarcely exist, nowhere arranged in longitudinal rows" (page 130). The type locality of the *C. suchus* species employed by Fuchs (2006) was not Egypt, but mistakenly "Niger" meaning the Senegal River, and based on the "Crocodile vert" or "Diasik" specimen collected by Michel Adanson. As shown in my Figure 1, the MNHNP 0.2724 specimen collected by Michel Adanson at the Senegal River has one obvious flank row of seven individual scutes. This is not the Fuchs (2006) predicted 4-5 flank rows, and further there is a remnant of the lower row, but it is reduced to a short lengthwise ("longitudinal" in Fuchs, 2006) row of unkeeled small ("granular" in Fuchs, 2006) scales at the midbody and midbelly level. Clearly the Figure 1 Senegal River crocodile has one obvious flank row, and this is different from the obvious two rows in Lake Turkana, but traces of the second (lower) row can perhaps be seen when the Figure 1 photo is viewed closely, and when the viewer is looking deliberately for vestigial traces of this ancestral flank row.

Conclusion

The name *Crocodylus niloticus pauciscutatus* Deraniyagala, 1948, is based on a single specimen that is expected to be in the natural history museum in Colombo, Sri Lanka. The hypothetical differentiation of *C. n. pauciscutatus* from its implied *C. n. niloticus* (and other potential subspecies) involves dorsal and ventral scale counts in the neck and body region, and also the special and obvious flank row(s) on the lateral surface of the body. Expanding the data in Ross (2006), there are now additional reasons to believe that the crocodiles in Lake Turkana did not key to their species-group name in the old CITES identification manual.

Literature Cited

01. Deraniyagala, P.E.P. (1948). Some scientific results of two visits to Africa.Spolia Zeylanica 25(2): 1-42 & pls. 1-14. Fuchs, K. (2006). The crocodile skin: important characteristics in identifying crocodilian species. Edition Chimaira: Frankfurt am Main, Germany.

02. Graham, A. and Beard, P. (1973). Eyelids of morning. A&W Visual Library by arrangement with New York Graphic Society: New York, N.Y., USA. Ross, F.D. (2006). Special crocs do not key to their name. Crocodile Specialist Group Newsletter 25(1): 18-19.

03. Ross, F.D. (2012a). Mark Van Tomme died at age 30. Crocodile Specialist Group Newsletter 31(4): 21-23.

04. Ross, F.D. (2012b). How C.A. Ross got into crocodiles, and some Fuchs content. Pp. 19-30 *in* Crocodiles. Proceedings of the 21st Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.

05. Ross, F.D. (2012c). C. Andy Ross papers, crocodile scales and Angel Alcala. Pp. 31-48 *in* Crocodiles. Proceedings of the 21st Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.

06. Ross, F.D. and Mayer, G.C. (1983). On the dorsal armor of the Crocodilia. Pp. 305-331 *in* Advances in herpetology and evolutionary biology. ed.

07. A.G.J. Rhodin & K. Miyata. Museum of Comparative Zoology, Harvard University: Cambridge, Mass., USA.

08. Rüppell, E. (1826) is actually Cretzschmar (1826). Fortgesesste Mittdeilungen über Eduard Rüppell's (Mitgl. dieser Gesellschaft) Reisen in Egypten und Nubien. Iris, Unterhaltungsblatt für Freunde des schönen und Rüsslichen (Frankfurt am Main) 25: 97-100.

09. Trutnau, L. and Sommerlad, R. (2006). Crocodilians: their natural history & captive husbandry. Edition Chimaira: Frankfurt am Main.

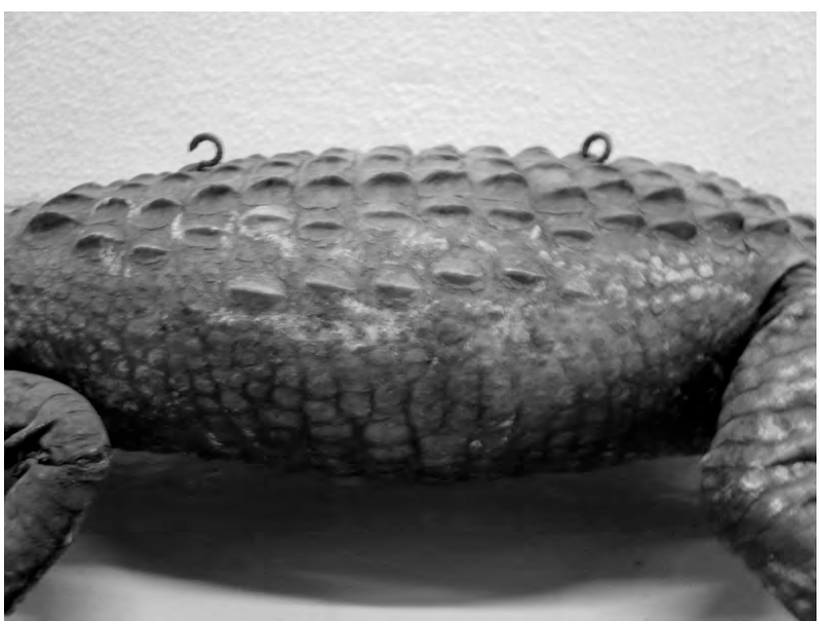

Figure 1. From the Senegal region, this mesorostrine African crocodilian (MNHNP 7524) has five or more really big flank scales, and these scutes are arranged in a single row. Photo by Ashley Pearcy.

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN SSC Crocodile Specialist Group
pp 301 - 308

CSG Thematic and Working Group Reports

Human-Crocodile Conflict Working Group

1. Participants: Charlie Manolis (Chair), Christine Lippai, Erin Britton, Adam Britton, Colin Stevenson, Ashley Pearcy, Rob Gandola, Akira Matsuda, Raju Vyas, Tarun Nair, Phil Steele, Oswald Bracken, Rambli, Brian Wright, Brandon Sideleau, R.J. Rao, Hiran Goonewardene, Abhijit Das, Jigar Upadhyay, Snehal Bhavsar

2. Crocodile Attack Database: Adam Britton and Brandon Sideleau provided an update on development of an online database for crocodilian attacks (www.crocodile-attack.com).
   - A grant from Charles Darwin University (Darwin, Australia) will allow the website search engine to be developed.
   - The website is effectively a data gathering tool and will include elements such as Country Trends and will identify 'Hotspots'.
   - It is proposed that CSG members will be able to register and use the site. Initial access may be to summary tables and maps, but "deeper" access to the data will also be possible.
   - Brandon will send out a copy of the online form that people will be able use to submit attack data (injury/fatality on humans only).
   - The HCCWG will have the opportunity on comment on the website as it is being constructed.
   - Around $1100 per year will be required to maintain the database (eg hosting). Major upgrades of the site would require additional funding.
   - General agreement that would be a useful tool, although it was also recognized that data could easily be misinterpreted.

3. HCC Facebook and Google Groups: Following the Manaus meeting (2010), a HCC Facebook page and HCC Google Group were posted. Initial interest was good, but the initiative has subsequently faltered. Many people were not aware of the Facebook page. A link will be placed on the CSG website, and the sites monitored with a view to revitalizing them.

4. HCC Case Studies: The Chair indicated that people will be approached to provide information on specific case studies dealing with HCC and mitigation measures, for incorporation into the CSG website, with links to the Crocodilian Capacity Building Manual that is currently being developed.

5. Environmental monitoring**:** Ashley Pearcy raised the issue of whether environmental modeling could allow a level of prediction of HCC, and thereby allow mitigation to be more targeted.

6. 23rd Working Meeting: The Chair gave a summary of the proposed HCC session for the 23rd working meeting (Louisiana, May 2014).

At Plenary, the CSG Chair raised some concerns that an independent website on HCC, which aims to use data from CSG members, may be perceived as representing the CSG and the collective knowledge on conservation, research and management that it possesses. Enquiries for assistance with HCC issues may thus be directed to a website rather than the CSG.

Veterinary Science Group

This CSG Veterinary Science Group meeting gave the attending members an opportunity to meet to review and update the content of the report capturing the outcome of the meeting held in Manila 12 months ago. This was also a great occasion to connect and strengthen our relationships.

1. Worthwhileness of the CSG Veterinary Science group mailing list

In Manila the group concluded that it can be more true to its mission. Over the last 12 months the queries presented to the CSG-vet mailing list were met with limited but useful responses. The level of response can be described as adequate and we are thus still far from our aspiration of excellence. In Manila the group also decided to spread the word amongst herpetological groups, farming associations and zoological park associations that such the Veterinary Science group exists. The desired outcome is that as the offer of help becomes known, those in need will take advantage of it.

The update on this point is as follows

1.1. Matt Plummer, who is now in charge of a number of farming operations in Australia, has started promoting awareness amongst Australian farmers. Previous contact with individuals was met with some interest. Marisa Tellez contacted a number of American herpetological circles. Pablo Siroski, one of our active contributors on the web-based vet group, could not attend this meeting. Paolo Martelli had no update and Kent Vliet volunteered to take over his task of contacting AZA, EAZA and AAZ as he is already active on the AZA and EAZA. Background information and message was provided. Samuel Martin contacted the French Vet Zoo Association (AFVPZ) as well as other crocodile caretakers. We do not expect an immediate increase in demand for CSG-Vet input. We must continue to commit time to responding to the queries we receive.

1.2. On Charlie Manolis' recommendation, Paolo invited Cathy Shilton to join the Veterinary Science group. We are grateful and fortunate that that she has accepted with enthusiasm. Cathy immediately became an active member, already contributing very significantly to the Colombo workshop and meeting.

2. CSG Website

Over the last 12 months the following documents were added to the CSG website.

a. Necropsy procedures in English, French and Spanish translation - thank-you Samuel Martin and Luis Sigler.
b. Anesthesia literature references (up to 2010) - thank-you Anabelle Olsson.
c. Link to histopathology site.

3. Review the list of relevant research topics encouraged by CSG

These were areas of veterinary science and medicine that will benefit crocodilian medicine, conservation and biology. They were not revisited at the Sri Lanka meeting:

- anatomy
- immunology acquired and innate
- Stress: stress indicators, response to stress, stress monitoring, patho-physiological effects of stress
- epidemiology emerging diseases and biosecurity, including at international levels
- nutrition
- health assessment and screening in general and in the context of reintroduction following IUCN reintroduction specialist group
- croc specific veterinary training of managers and veterinarians in various areas.
- Behavior , medical and husbandry training of the animals
- husbandry and welfare, electric immobilization
- intellect, cognition
- endocrinology/reproductive physiology
- genetics
- physiology

4. Use of electro-immobilization

We had unanimously agreed on the following in Manila: *"Like every tool, electrical immobilization must be used by trained staff using well maintained equipment. To the best of our observations there are no reasons to consider that EI is more detrimental than manual capture to the individual or the group it is in. There is evidence that it less stressful to the animal (Franklin et al.). Studies are underway and more specific studies are encouraged."*

Update**:** One of our CSG-vet members, Dr. Silke Pfitzer, has completed a thesis titled "Physiological Parameters of Farmed Nile Crocodiles (*Crocodylus niloticus*) Captured Manually and by Electrical Immobilization". The thesis is being reviewed as we meet. The important issue of whether the electro-immobilization leads to unconsciousness

was raised. See also point 5.

The following are pending and have been assigned

Topic	Action	Target
Veterinary procedures (general examination, sampling, medication etc.)	Samuel Martin Terry Cullen	May 2013, no update.
Literature resources	Kent Vliet Val Lance Paolo Martelli Charlie Manolis	Pending political and legal issues. We have been unable to progress on the issue of copyrights. It was decided that Kent will make available a list of his entire collection of papers, books and journals. We realize this will be challenging to search but it will have the merit of being freely and globally available for those motivated enough to use it.
Database of gross images of normal tissues and pathology with labels	Cathy Shilton	Cathy will add to the document used for the workshop showing a collection of necropsy photos. This will be posted as PDF and will offer a valuable resource for fellow vets. Furthermore Cathy will contact the WDA to see if a link specific for crocodilians can be shared.
Introduction techniques for new animals in captivity	Samuel Martin Terry Cullen Geoff McClure	May 2013, document prepared by Geoff, under review.
Parasite database Xcel format	Marisa Tellez	December 2012. Subject to publishing issues. Very likely to be made available by CSG meeting in 2014.
Manual for parasite collection/preservation by Marisa Tellez	Marisa Tellez Paolo Martelli	Had been lost in the mail, is now available and will be published shortly.
Share information on histopath database technicalities to facilitate adding material	Paolo Martelli	August 2012. The website owners are no longer available for further uploads but existing database will persist. We have not located a university that will allow scanning and posting for free.
Facilitate movement of histopathology slides in and out of the USA	Terry Cullen	Update next CSG meeting, 2014
Scientifically sound study on effect of various electrical parameters on crocodiles subjected to EI	Marc Merchant	Pending review of Dr. Silke Pfitzer's thesis to refine needs, see below

5. Present and assign tasks for the capacity building group

5.1. Euthanasia/killing methods. Paolo presented a draft that was reviewed collectively.

a. Stunning by shooting or captive bolt followed by pithing. At this moment electrical immobilization is assumed to cause unconsciousness as in other species. However no specific data exist in crocodiles to support this so an important caveat is placed on pithing after

immobilization that the crocodile must appear to be unconscious (unresponsive and unaware) before pithing.

b. Also refer to the document by the expert panel on humane euthanasia of reptiles to choose methods suitable for crocodilians (the document is biased towards pythons).

c. Pithing without stunning is not a humane method of euthanasia or culling and should be discouraged. However the group is well aware of how common this practice is and of cultural and legal differences. Also stunning a medium or large crocodilian without proper equipment may not be possible, in which case it is preferable to swiftly carry out pithing without stunning than to attempt traumatic destruction of the brain repeatedly. We encourage CSG members to increase awareness that this practice is not ideal and should be replaced with one of the above.

d. Bleeding without pithing is not acceptable by any standard. Pithing is an absolute requirement and should be done in the unconscious animal. We encourage CSG to work towards building awareness

Method	Acceptability
Captive-bolt pistol	Alone or with a subsequent method to ensure death (pithing) if the brain is not immediately destroyed.
Blow to the head with a hard implement	In combination with a subsequent method to ensure death (pithing) if the animal is only stunned.
Decapitation	With a subsequent method to ensure death (pithing or blunt trauma).
Shooting	With a bullet appropriate for size of the animal and in line with relevant legislation, training and safety protocols (effective, quick and humane). Particularly in conjunction with spinal severance and pithing (used on crocodiles). When the distance between the animal and the shooter is minimized in order to reduce margin for error for "missing" the brain.
Pithing	After prior stunning (captive-bolt or blow) or decapitation and as method to ensure death.
Cervical Dislocation, if performed in the correct size animal (<200 g)	With proper technique and followed by another procedure to ensure death.
Injection	Depending on the context and the experience/training of the person (e.g. veterinarian, researchers).

Good questions that arose from this discussion are:

1. Can we recommend voltages, frequencies and length of usage for electro- immobilization? No we cannot at this stage. It is a field that needs further scrutiny. In domestic animals it has been shown that higher frequencies do not lead to unconsciousness and cause pain. Data is lacking in crocodilians.
2. Is an electrically immobilized animal unconscious and can E-I be used as stunning method prior to pithing? Studies in food animals show that effectiveness, pain and unconsciousness are a function of frequency, voltage and duration. Such studies are lacking in crocodilians.

5.2. Share with the capacity building committee what are the (web) resources or resources that the members use. Links can be added to the CSG website. It was clear that none of us was really clear as what the capacity building referred to. We will seek further guidance from Ashley Pearcy.

6. Other matters

6.1. With Chris Banks, to request people maintaining adult or breeder *C. mindorensis* to submit a 'floor plan' and photo/s of their breeder pen design with comments on the behavior/compatibility of their animals. Submissions will be collated to ascertain any features of pen design that will affect breeding. All submissions will be acknowledged and presented at the next CSG working meeting in 2014. This initiative will be included in a database - it should be noted that there is no current 'studbook'. This has been completed, was presented by Geoff McClure in Negombo and was added to the Manila Proceedings.

6.2. The crocodile husbandry challenge - to design self-cleaning accommodation for 50 2-year-old crocodiles. Proposals will be presented at the 2014 CSG meeting.

7. Any other matters

Workshop at the Colombo Zoo: attendance was approximately 100 participants of all boards in contrast to the intended 25-30 vets and wildlife officials only. As a result the workshop turned out rather different from what we had intended. However we are not disappointed at all and the feedback from the workshop has been overwhelmingly positive, with most people finding it useful and wanting more workshops. Lessons learnt are: A well-managed registration, a clearer description of the workshop scope and content and a proper assessment form.

The group unanimously would like to see workshops included in future CSG working meetings. The following areas where identified as useful to seasoned or beginning professionals and students alike. This list is not exhaustive:

- veterinary techniques
  - general exam
  - special examinations
  - anesthesia
  - surgical techniques
- translocation and transport of large crocodilians
- field biology techniques
  - measurements
  - stomach flush
  - marking and identification
  - bleeding
  - population and nest surveys
- captive rearing techniques
  - egg handling
  - care of hatchling
  - slaughter
- methods of capture in different situations and good restraint practices
  - on land
  - in water
  - from boat
  - trapping

Mark Merchant and Marisa Tellez will do their best to organize a 4-hour workshop on field biology at the CSG meeting in 2014. This is very short notice but hopefully it will be possible. Most likely it will include measurements, capture from a boat, bleeding, etc.

CSG Tomistoma Task Force

Participants: Bruce Shwedick (Chair), Colin Stevenson, Kent Vliet, Jen Brueggen, Szu- Lung Chen, Paolo Martelli, Rambli Ahmad, Oswald Braken Tisen, Tarun Nair, Nirmal Kulkarni, Shakthi Sritharan, Fabian Schmidt, Akira Matsuda, Agata Staniewicz, Samuel Martin, Gowri Mallapur

1. Meeting started with introductions, first by CSG-TTF chairman Bruce Shwedick, about his involvement with TTF and a brief history. TTF was initiated in Gainesville Florida in 2002. Since then several people have held the post, starting with Grahame Webb, then Ralf Sommerlad, and followed by Rob Stuebing. The other attendees introduced themselves and their interest in the group or work related to Tomistoma.

2. Bruce Shwedick committed to remaining in the position of Chair for as long as is needed.

3. The recent TTF report to the Steering Committee will be published on the CSG website, together with the complete

minutes of the meeting.

4. The aim of the TTF will be to now move its main focus of attention to Asia.

5. Updates from the last meeting. Re finances, the TTF has a fund of $US45,000 available. Recently, a Night for the Crocs fund-raising event resulted in just over $US7100.

6. Revised draft assessment: This has been completed and the consensus after consultation with CSG experts is to move Tomistoma to "Vulnerable". The CSG review is awaited. Colin Stevenson mentioned that this review was initiated because more information is available since the last assessment. Paolo Martelli raised the question that seeing more animals and greater accessibility may mean more encroachments and pressures.

7. The TTF website will be integrated into the CSG's website (www.iucncsg.org), and key portions will be translated into Bahasa Malay, Bahasa Indonesian, Japanese and Chinese.

8. Recommendations from 2008 Tomistoma Workshop will be updated and re-circulated among the TTF core members and to participants of today's meeting. Those CSG members with specific interests and expertise will be given an opportunity to take on responsibilities. These recommendations are divided into three areas: Captive Husbandry, Field Research and Developing Partnerships for Conservation.

9. Few points to consider were put forth to the attendees
   a. Quick Surveys: Region wide rapid assessment surveys

   b. Could the existing *C. porosus* 3M Program in Sarawak be helpful for the monitoring and conservation of Tomistoma?

   c. What is the best way to facilitate activities in Asia-suggestions included working with Singapore Zoo that has supported CSG-TTF efforts in the past, as well as Zoo Negara and Taipei Zoo. Promote Tomistoma awareness and conservation issues through lectures at museums, local community organizations, businesses and social events.

   d. The Tomistoma Task Force has been comprised primarily of CSG members from outside of the range states. Bruce Shwedick suggested setting a 10-year goal by which the activities and conservation efforts of the CSG-TTF would by conducted primarily by CSG members and/or others from within the range states.

10. General Discussions

Oswald Braken (Sarawak Forestry Department): The main governmental issues in Malaysia/Sarawak are economic and social. How will funding for work come? With the involvement of the CSG and increased people involvement the work profile can be augmented. The governmental priority for Tomistoma is currently low is as there is no economic benefit from this crocodile and there are no serious HCC issues. One of the positive suggestions for Tomistoma would be for people to be able to see it in its habitat.

Agata: It is currently hard to find people in Indonesia interested in studying crocodiles. Currently there is some local interest in studying fish and some associated parameters.

Colin asked about the outcome of the workshop in Thailand in 2008. Did anyone from the Range State seem promising?

Bruce has had recent and on-going discussions with Fernando Potess of the PRCF about initiating a long-term conservation project in West Kalimantan. CSG-TTF is currently awaiting a revised proposal.

Bruce: The CSG Executive Committee met with him have suggested to send a delegation to universities in that region on a " fact finding " mission which could culminate with a governmental meeting in Jakarta. The delegation would include Bruce and possibly Charlie Manolis. This mission would also attempt to identify potential students that could receive funding through the CSG Student Grant Program.

Kent Vliet: Applauded the Chairman and the vision and forward thinking. He mentioned that it is important to identify a diverse range of partners, not only universities, museums, government authorities, but established conservation organizations like WCS, CI & FFI. Their help could be essential due to their familiarity in which to speed the process of finding partners and understanding political situations and ramifications.

Kent also suggested that the CSG-TTF should continue to raise funds as a nucleus to establish its roots and grow. Maybe this fund raising activity can be handed over to the zoo community.

Hosting an IUCN meeting is very powerful in making ones presence felt and to evoke a response from the government. Kent also suggested that Sarawak host a full working meeting of the CSG with Government officials from Range States. This contributes to a significant increase in government awareness and availability of funding opportunities from range countries.
The pros and cons of a full meeting versus a regional one were also discussed. The impact of a full meeting is much greater and there is much greater worldwide attention. The larger meeting can lead into a series of smaller regional specific, target-based meetings

Oswald: Government of Sarawak has a grant for organizing programs with international participation in conferences. This will need a guarantee of international attendance. In 2014 in Borneo a program on *C. porosus* is planned and an additional day for Tomistoma workshop can be added easily. This is planned for the mid-year. The response from the attendees at this meeting was positive. It is important to have local and regional experts at this meeting.

Imanul Huda from West Kalimantan has been proposed for new membership to the CSG. Samuel Martin mentioned an individual from Sumatra who has a gibbon rescue centre and very unique methods for doing surveys and monitoring local wildlife. Samuel to facilitate communication.
Non-traditional methods for survey of Tomistoma should be considered, such as stationary surveys being used by Mark Auliya, Agata S. and Jeff Lang currently. Camera trapping works better for *C. siamensis* which came to the traps with rats and near nests. Agata currently uses canoes due to the topography of the area in question in Lake Mesangat. Another suggestion was to use video-equipped drones with high-resolution video and GPS.

Secondary information about Tomistoma from fishermen is sometimes received. Rob Stuebing has initiated a small reward program for local fishermen who do not collect Tomistoma eggs for food and allow successful hatching.

Paolo mentioned that he believed it was essential to separate science and conservation.

Colin: It is important to tie in with other organizations working in that area.

Kent: Meld with the other IUCN specialist groups in the area and share resources. Aid with materials and small grants.

Jen Bruggen spoke about her experience at an eco lodge in Kalimantan on their trip to an Orangutan Reserve. She observed 11 animals during the day and two at night. The river they traveled on had an orangutan reserve on one bank and a palm oil plantation on the other.

Some alternative survey techniques: Recording of vocalization/infra sounds. Losing equipment is a hazard. Acoustically distinct characters may be identified.
A rangewide GIS project to make detailed distribution maps of habitats that had historically housed crocodiles was suggested. This can help assign priority to habitat and increase communication among people across boundaries.

The meeting attendees provided their contact information in order to continue these and other Tomistoma related discussions in the future.

Zoos Group

Participants: Kent Vliet, Jen Brueggen, John Brueggen, Fabian Schmidt, Geoff McClure, Colin Stevenson, Gowri Mallapur, Shakthi Sritharan, Alex Meurer, Mark Merchant, Sally Isberg, Cathy Shilton, Matt Plummer, Nikhil Whitaker

Brief History
Six years ago the Zoos and Community Education thematic group was created with the intent of building a community of zoo professionals from within the CSG. However, there has not been a lot of forward momentum of the group. A Google listserv was created to encourage conversation among the international zoo professionals, which includes mostly North American and European zoos. Communication from Latin American and Australian zoos has been less frequent, and from Asian and African zoos has been rarer still. Currently, there are about 40 members on the Google listserv. The group was split into two separate groups in 2012: Zoos; and, Public Education and Community Participation.

Communication within the group includes *in-situ* and *ex-situ* crocodilian conservation projects, as well as enclosure design, breeding, behavior, etc. within the zoo community to the improvement of crocodilian husbandry and management.

Action Plans
1. Build membership within the group, especially from Asian and African regions.
    a. Current members should strongly consider recruitment of new members from other zoos that could be relevant to significant contributions to crocodilian conservation.

b. Could there be a better way to communicate than the Google listserv?

c. Members are required to have Google accounts in order to receive the e-mails, however this is a simple registration.

2. Long-range goals, such as contributions to the CSG. Need ideas and discussions.

3. There will be a special half-day session devoted to zoos at the CSG meeting in 2014.

a. The primary theme will be the contribution and impact of zoos to crocodilian conservation.

b. Contributions to all aspects of crocodilian biology (behavior, anatomy, reproduction, veterinary science, etc.) achieved by research and observations under captive care can also be highlighted.

c. At least 6-8 speakers. We must identify these speakers and topics by the end of summer 2013 to report to Mark Merchant for scheduling purposes.

d. Presentations may consist of several 15 minute allotments, with perhaps a few 30 minutes or longer.

e. Care will be taken ensure that North American speakers do not dominate the time, but to have presentations from a wide range of speakers from many represented regions.

f. A strong selection process will be used to select presentations versus posters.

g. Design the presentations and schedule, so as to not discuss similar ideas and projects.

h. Presentations would ideally be grand projects and commitments and highlight the many ways that the zoo community contributes to *in-situ* conservation and the biology of crocodilians.

i. How much money is directed towards conservation from the zoo community? Many zoos and private groups make contributions to support international projects. We need to try to quantify this. Colin Stevenson (Madras Crocodile Bank Trust) says he may be able to put this together.

j. Conservation projects supported by the zoo community tend to emphasize more critically endangered species, rather than species that are valued for commercial uses. So this may be one important element to the theme of the workshop.

k. Is there need for a zoo workshop committee to organize this event? We will see. Kent does not wish to plan it all.

l. Mark Merchant offered ideas such as the financial contributions of zoos to conservation and research, reintroduction programs, as well as the behaviors observed within zoos that have added to the general knowledge of crocodilians.

It is important for keepers to realize they can offer these kinds of contributions to the crocodilian scientific community, including reproductive physiology and husbandry.

The group engaged in a discussion of the standards of space for husbandry, as this had been a topic brought up in the CSG Steering Committee meeting; Kent was continuing to draft a statement in collaboration from Perran Ross, Alex Meurer and Paolo Martelli. A short statement was made for the response of the CSG to international inquiries. To be presented at the end of the meeting in Sri Lanka.